# ENGINEERING NEWS
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NEW WATER SUPPLY AND PURIFICATION WORKS for Columbus, O., at an estimated cost of some $3,800,000, have been recommended by Mr. S. M. Gray, M. Am. Soc. C. E., of Providence, R. I. The plans are based on a population of 240,000 in 1925; a present daily consumption of 16,000,000 gallons, with a maximum of 24,000,000 gallons, which figures will be increased to 30,000,000 and 45,000,000 gallons, respectively, in 25 years. The plan proposed includes a high masonry concrete granite faced dam and an impounding reservoir on the Scioto River, the development of water power there, a 60-in. steel conduit, 20,000,000-gallon mechanical filtration and water softening plant, 12,000,000-gallon clear water basin, new pumping station, a reinforcement of the distribution system, and the erection of three standpipes. It is not necessary to do all this work at once, but the portion recommended for immediate construction would cost about $2,200,000. Mr. Gray estimates that mechanical would be cheaper than slow sand filtration by $188,000 for first cost and $19,792 per year for operation, on a basis of 20,000,000 gallons a day; and that for both filtration and softening mechanical filtration is cheaper by $32,357 a year. The additional expense due to softening the water is estimated at $58,855 a year, but Mr. Gray believes that the people of Columbus are now paying $221,000 a year on account of hard water.

PLANS FOR A WATER-STORAGE RESERVOIR for Newark, N. J., have been submitted to the Street and Water Commissioners by Mr. M. R. Sherrerd, M. Am. Soc. C. E., Engineer of the water department. The reservoir is to be located a number of miles northwest of Newark, at Cedar Grove, just west of First Mountain. Three earth dams of fair size will be required. The estimated cost of the reservoir is $1,500,000. It will be filled from the present Pequannock supply mains.

A SAND WASHING AND DRYING PLANT for the sewage filtration beds at Reading, Pa., was recommended by the Board of Public Works of that city in the latter part of February. In its communication to the city council the board wrote as follows:

We have been, up to this time, using the old sand, but with the advent of cold weather, it has been impossible to do this any longer, as the sand banks have become frozen. This will necessitate the purchase of new sand. We will have this difficulty from year to year, and it is estimated that the cost of the sand alone will be $4,000 per year. A sufficient cleaning and drying plant can be erected for $9,000. It is obvious that the plan will pay for itself in the course of several years. When such a plant is completed, the sand can be used over and over again, reducing the cost of replacing the sand to a minimum. If we are obliged to purchase new sand yearly and store the same, as we have done since the disposal plant has been in operation, it will be necessary that additional ground be purchased, as the present ground adjacent to the plant will be inadequate for any further storage of sand.

THE STATE ENGINEER OF UTAH will have enlarged powers after May 24, when a new act, defining his duties, will go into effect. The act really covers the whole subject of the control of water for irrigation. It provides for the measurement of streams, the formation of irrigation districts, the division of water among irrigators, the prevention of water waste, and the filing of plans for, and the supervision of the construction of dams. The act makes 1 cu. ft. of water per second the legal standard for the measurement of water in the state. The salary of the state engineer under the new act is $2,000 a year.

THE PENNSYLVANIA CANAL, a part of the state canal system, is to be abandoned by a unanimous vote of the stockholders on April 11. The part of the canal effected by this vote extends along the Susquehanna River, from Columbia to Nanticoke, a distance of 114 miles, and from Northumberland to Loyalsock, 30 miles. This canal was built by the state of Pennsylvania under an act approved by Governor Schultz, in 1826; in June, 1857, the canal and the state railway, forming the main line from Philadelphia to Pittsburg, were sold to the Pennsylvania R. R. Co. for $7,500,000. The branch lines were sold in May, 1859, for $3,781,250. The Pennsylvania Canal Co. was organized in 1866, and became the owner of all these canals. This company will be kept intact until 1910, when the 6% mortgage bonds mature, on $2,000,000 of which still outstanding the Pennsylvania R. R. Co. guarantees the interest.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Wheeling & Lake Erie Ry. at Rexford, O., on April 6. A freight train was derailed by a rock that had rolled across the track and two men were killed.

A BRIDGE GAVE WAY under a street car of the Syracuse Rapid Transit Co., of Syracuse, N. Y., on April 6, and the car and its 60 passengers were dropped to the dry bed of the Oswego Canal, 30 ft. below. About 40 persons were injured, but it is not believed that any deaths will result. Had the canal been filled with water many undoubtedly would have perished. The bridge was about 80 ft. long and 60 ft. wide.

ELECTROLYSIS OF UNDERGROUND PIPES in Brooklyn, N. Y., has been brought to the attention of the Commissioner of Public Buildings, Lighting and Supplies by the water department of the borough, with the request that the subject be investigated by that department, under whose jurisdiction it is placed by the charter of Greater New York. Mr. Jas. J. Kirwin, Deputy Commissioner of Public Buildings, Lighting and Supplies for Brooklyn, suggests that the consulting engineer of lighting and electricity be requested to outline a plan for investigating the matter.

THE WELSBACH GAS-LIGHT MANTLE has been greatly improved, according to a consular report from Berlin, by the addition of silica and zirconia to the thoria and ceria of which the mantle is composed, the two substances being added to the impregnating solution in equal proportions. The mixture is said to result in greatly increased strength and life of the mantles and the elimination of shrinkage, as well as increased candle power. It is said to also permit the addition of other ingredients which improve the quality of the light emitted.

THE COMPARATIVE COST OF ACETYLENE, per effective horse-power, was fixed as follows, as the result of recent experiments in Berlin, says the "Schweizerische Bauzeitung" of Jan. 26:

| | Developed 10 HP. Cts. | 20 HP. Cts. | 30 HP. Cts. |
|---|---|---|---|
| Acetylene gas | 5.85 | 5.62 | 5.54 |
| Lighting gas | 2.61 | 2.45 | 2.38 |
| Power gas | 2.90 | 2.19 | 1.95 |
| Alcohol | 4.04 | 3.86 | 3.81 |
| Petroleum | 2.56 | 2.38 | 2.32 |
| Benzine | 3.76 | 3.59 | 3.52 |
| Electricity | 3.60 | 3.55 | 3.46 |

These figures, given in U. S. currency, are based upon Berlin prices of materials, and include all the cost of installation, repairs and sinking fund. The figures represent the cost of an effective horse-power hour in the three types of engines noted. Our contemporary concludes, as the result of these experiments, that after all the difficulties of construction and operation are solved, in connection with the use of acetylene motors, the relatively high cost of this motive force will be a serious obstacle to its industrial employment.

THE LIGHTING of railway carriages, stations, signals, etc., is being investigated by a special commission appointed by the Minister of Ways of Communication of Russia. Special attention is given to acetylene, and all information regarding the application of this and other lighting materials will be gratefully received and taken into consideration by the commission at St. Petersburg.

THE KERN RIVER OIL DISTRICT in California is now producing about 150,000 barrels of petroleum per month. About 200 wells have been drilled and nearly as many more are being put down. The oil produced is a heavy fuel oil, which is being chiefly used as a substitute for coal. The district in which most of the wells are located is a tract of about 8,000 acres about four miles from Bakersfield, in the San Joaquin Valley.

GAS ENGINES FOR MINE PUMPING are proposed for the South Staffordshire coal mining district in England. The mines in this district are kept drained by a special commission and the expense of the work is very great. It is proposed to substitute gas engines using Mond producer gas for the present steam pumping engines, and a saving of 50% in the cost of pumping is anticipated. A bill to permit the manufacture and distribution of the Mond gas is shortly to be introduced in Parliament, and the maximum price of the gas is to be fixed at 8 cts. per M. ft., or 6 cts. for large consumers. The gas has a heating value of about 140 to 150 B. T. U. per ft., or about one-fifth the heating value of ordinary illuminating gas.

THE FUEL QUESTION is becoming a pressing one in Russia. The thick forests covering wide areas in some parts of the Empire are rapidly becoming depleted, largely because of the rapid growth of railways. Recourse is now being had to peat, which occurs in considerable quantities throughout the country. A peat-coking oven has been invented by Engineer Zigler, of Oldenburg, by means of which a fuel of superior quality is obtained at a very moderate cost, about one-quarter of that of fire wood, which costs $18 to $20 a cubic sazhen in St. Petersburg. Newcastle coal costs 80% more than peat, turf bricks manufactured at the Irinooka plant, near St. Petersburg, 60%, and naphtha employed as fuel 58%. A peat coking plant on the Zigler system has been established near the town of Oldenburg. On the invitation of Prince Hilkoff, the Minister of Ways of Communication, a plant is being constructed near the town of Twer on the Nicholas Ry., and the product will be used mainly as fuel for locomotives. The construction and installation of this plant is in charge of Engineer Karysheff. The total cost of the 15 buildings with full equipment and a branch railway line to the peat bog will amount to $1,250,000.

A U. S. COALING STATION IN MEXICO, at Pichalinqui, on the west coast, has been established, and 5,000 tons of coal are now on the way there from Baltimore. This station, by full authorization of the Mexican government, is located on California Bay, at the extreme end of the peninsula known as Lower California. About $25,000 has already been expended in docks and coal-storage bins, and the equipment for loading is on the most modern lines.

BIDS FOR THE PORT IMPROVEMENTS at Rosario, in Argentina, will be received until Dec. 10, 1901, at London, and until Jan. 10, 1902, at Buenos Ayres, the time having been extended as above.

THE RECHARTING OF THE WATERS of the Philippines has been commenced by the U. S. Coast Survey, and a survey party has already sailed under the charge of G. R. Putnam, of the Coast Survey. The unsafe waters will be first surveyed, to correct existing charts. In this connection it may also be said that the Navy Department has detailed Rear-Admirals Henry C. Taylor and A. T. Mensal and C. C. Wolcott, of the Civil Engineer Corps, U. S. N., to prepare plans and submit estimates of cost for a naval stronghold and station in Subig Bay, about 40 miles from Manila. The plans contemplate a thoroughly equipped repair station, with docks, shops, etc., in addition to the fortifications.

A SPECIAL FORESTRY DIVISION of the Department of the Interior is being organized by Secretary Hitchcock, with a view of consolidating into one division of his department work now divided between several divisions and the Department of Agriculture. The lumbering operations in the Northwest, which have been causing scandal lately, are to be especially provided for; and the general management of the government forests is to be better cared for at the same time.

A SAILING RECORD OF 18½ DAYS, from Liverpool to the Delaware Capes, was lately made by the four-masted "bark" "Kenilworth." The best previous record was made by the ship "A. J. Ropes," which made the run from Liverpool to New York in 19 days, three years ago. The "Kenilworth" traveled 120 miles more than the "A. J. Ropes." Both of these ships are American, though the "Kenilworth" was Scotch built, was burned, and rebuilt in this country. The same ship made the run from San Francisco to New York in 103 days, and from Valparaiso to New York in 65 days. She left San Francisco on Nov. 7, 1900, and reached Liverpool, with a cargo of grain, on March 11, 1901, or in 124 days.

THE GREAT NORTHERN STEAMSHIP CO. is having built at the New London yards of the Eastern Shipbuilding Co. for the Pacific trade, two ships that will have greater tonnage and displacement than the "Celtic," recently launched at Belfast, Ireland, for the White Star Co. These two American steamships will be deeper and fuller in the hulls than the "Celtic"; and they will each have a tonnage of 21,000 and a load displacement of 38,400, against 36,700 tons extreme load displacement for the White Star steamship. Their passenger capacity will quite equal, and their coal and cargo capacity will slightly exceed the figures for the "Celtic."

## THE SOULANGES CANAL WORKS, CANADA.

By C. R. Coultée, Assoc. M. Can. Soc. C. E.*

I.

Between Prescott and Montreal the freight traffic of the St. Lawrence River is, on account of rapids, forced to take to canals. Fourteen-foot navigation has been secured, and boats of this draft can pass from Lake Superior to tide water. The Soulanges Canal is the link in this chain of ship canals, that replaces the old Beauharnois Canal, which was 9-ft. draft only. The location, design of locks and superintendence of construction have been entirely in the hands of Mr. Thomas Monro, Past-President of the Canadian Society of Civil Engineers. His 20 years' experience as engineer of the Welland Canal, coupled with studies of foreign practice, have led to the adoption of some entirely new features, and the canal is an example of matured practice in hydraulic engineering of this class.

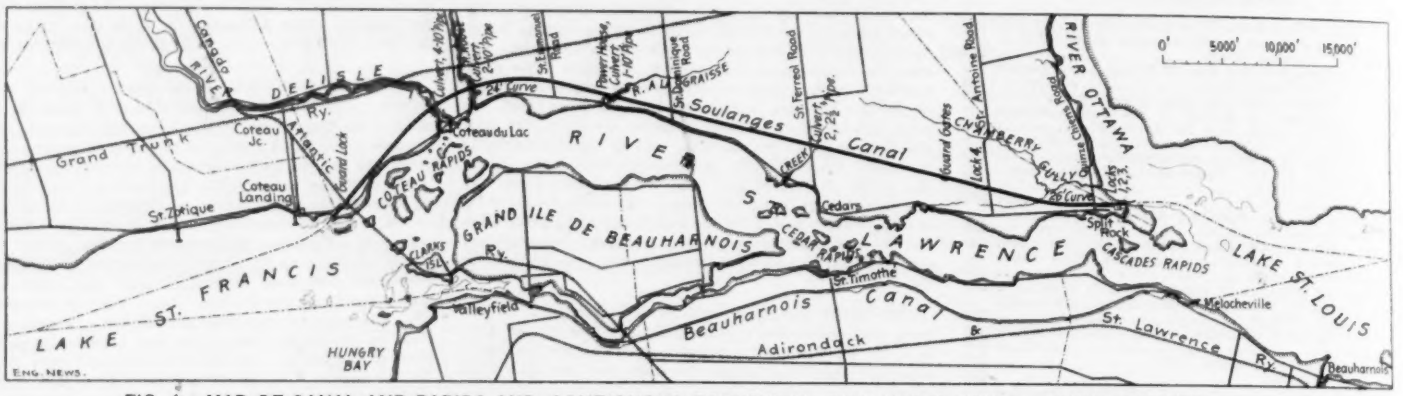


FIG. 1. MAP OF CANAL AND RAPIDS AND CONTIGUOUS TERRITORY; SOULANGES CANAL WORKS, CANADA.
Thomas Monro, Engineer.

The location on the north side of the St. Lawrence was decided upon as requiring less curvature, fewer locks, and because quicksand was in evidence on the south shore. In addition, the enlarging of the old canal would have led to many difficulties and unforeseen expense. From the general plan, Fig. 1, it will be seen that there are only two curves. The longer extends for 60° on a radius of 14,800 ft. (about 24'), and was necessitated by the great bend in the river itself. The shorter extends through 16°, on a radius of 12,800 ft. (about 27'). Both are so easy that for purposes of navigation the canal may be considered a straight line.

The supply of water was, of course, inexhaustible; therefore only its admission into the canal was to be considered. The cross-section of the canal prism, Fig. 2, is 100 ft. width at bottom, with 2 to 1 slopes throughout in rock or earth and 16 ft. of water at extreme low water. The area of prism at mean low water is about 2,400 sq. ft., or say four times the submerged transverse area of the typical vessel for its navigation. This section of canal is nowhere diminished, but on the contrary a larger area is given at bridges.

The admissible current was fixed at about 1 mile per hour, or say as high as 100 ft. per minute. The canal bottom, Fig. 3, has a fall of 0.1-ft. per mile, and the current serves to change the water and slightly aids the seaward traffic. The banks along the summit level are high enough to admit of the canal surface being raised to the highest water level of Lake St. Francis, and still be 3 ft. above water. This would give a depth of 20.5 ft. in the canal prism.

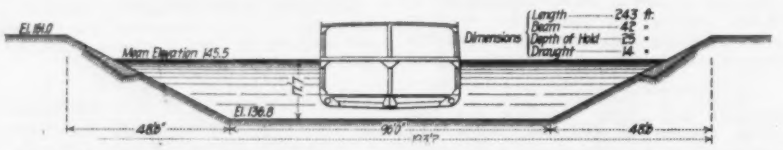


FIG. 2. TRANSVERSE SECTION OF CANAL PRISM; SOULANGES CANAL WORKS, CANADA.

### PLAN, PROFILE AND CROSS-SECTION.

The Soulanges Canal, about 14 miles in length, couples Lake St. Louis, the expansion of the St. Lawrence above Lachine, with Lake St. Francis, the expansion below Cornwall. Lake St. Francis is generally 82.5 ft. higher than Lake St. Louis, and this is surmounted by five locks, the first three having the exceptionally high lift of 23.5 ft., the fourth a lift of 12 ft., and the head, or guard, lock, a lift of about 2 ft. The location on the

### GUARD LOCK.

A guard lock, Fig. 4, is located near where the axis of the canal intersects the original shore line. This protects the entire artificial channel to the east from an influx of Lake St. Francis: (1) were the summit level banks to break at any point, or (2) were it required to run the level dry for repair work. It also prevents the piling of the lake water into the eleven-mile summit level by westerly winds, whereby the banks might be overrun. Guard gates would not suffice, as, were the lake water to pile against them, it would be impossible to open them and admit vessels until the storm fell.

To feed the canal a supply race, Fig. 4, is provided to the south of the guard lock. Across the head of this is a weir consisting of a masonry wall pierced at the bottom by four arched openings 9 ft. wide and 10 ft. high. These openings are throttled by submerged "Stoney" valves which are exclusively used throughout the canal.

Splay walls extend above and below the guard lock to guide vessels in and out. Above the upper splay walls are two parallel piers 200 ft. apart and extending 1,600 ft. into the lake, which give mooring accommodation to boats awaiting locking.

Canals leading from rivers at the head of a rapid, are always subject to a current setting across their entrances. To obviate this means entering land higher up and increasing the cost of construction and land damages. So long, however, as the entrance is amply wide and deep enough to allow of boats swinging well in toward shore, the cross set of the current becomes a small matter even to tows.

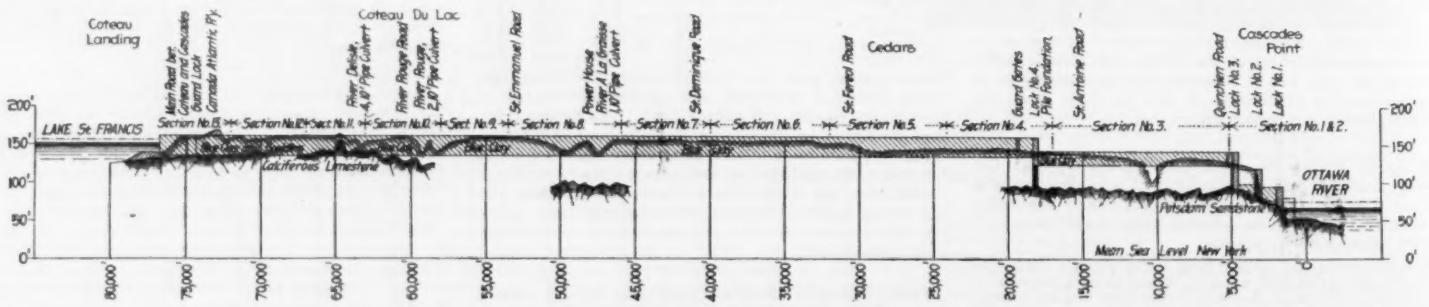


FIG. 3. PROFILE OF SOULANGES CANAL WORKS, CANADA.

### SUMMIT LEVEL.

The summit level has its top bank elevation at 161 (above sea), or the same height as the coping of the guard lock. By this means it is assured that the top of banks will always be well above the highest water at the entrance, which has been recorded as 157.5 above sea. This level is over 10½ miles in length, or 75% of the whole canal, which can be navigated without stop of any kind whatever. A depth of 20 ft. can be had if desired at high water, giving nearly 3,000 sq. ft. transverse area and 176 ft. width at the water line. This, of course, means speedy and safe navigation for large boats.

The bank protection consists of a notch cut along the 2 to 1 side slopes and solidly refilled with broken stone of various sizes, as indicated by Fig. 2. The face is finished with macadam rammed to a 2 to 1 slope, and the top line is finished with a rough coping, 6 ins. thick and 1 ft. wide, laid in 2½-ft. lengths. This cope is 3 ft. above the working level, and the base of the lining is 5 ft. vertically below water surface. There are no large boulders to become displaced and carry several others with them; but the 2-in. metal and fine grit form a knit slope, and repairs are easily made by dumping broken stone where required.

Sod is laid upon the slope above the coping and for a width of 5 ft. along the top of bank. Along the north bank, which is 50 ft. wide, a macad-

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amized public road is provided. Between this road and the edge of the canal is the pole line, bearing the power and light wires. All the poles are painted white, and every fourth one carries a 2,000-c. p. closed arc light. Along the north side trees are being planted, and the appearance of this artificial river is both finished and pleasing.

### CULVERTS.

Three small rivers are passed underneath this upper reach by means of culverts, the Delisle, the Rouge and the Grease.

DELISLE.—The Delisle is the largest, its flood flow sometimes nearing 300,000 cu. ft. per minute. Its channel was diverted slightly by straightening a bend and a rock foundation thus secured. In fact, all three streams were diverted somewhat, allowing the flow to continue uninterruptedly in the old channel during construction. Fig. 5 shows the details of the culvert construction. The foundation pit was 50 ft. wide, excavated in limestone rock. In this, four parallel lines of cast-iron pipe were laid. Each ring of the pipe was 10 ft. in diameter, 5 ft. in length and 1 in. thick, strengthened by three fillets. They were laid plain butt joints, and then the whole pit was filled with concrete, which was carried up 2 ft. over the iron. The rings provide against a bursting up-pressure, which would occur if the river were in flood and the canal were emptied for repair work. H. R. Ives & Co., of Montreal, Quebec, made the castings in a most creditable manner.

along the prism resembles a movable dam and piles the water at any restricted part of the channel. The currents thus created tend to swing vessels across the canal. To avoid this the prism area is increased at the bridges by excavating in rear of the pivot piers (Fig. 7). One arm of the bridge spans this side basin and the other spans the canal proper. Practically all the bridge masonry is concrete, only the copings and parapets being of stone. All ironwork is painted with white lead, and the graceful superstructures, contrasting with the green banks and adjacent woods, give quite a picturesque effect. On top of each bridge a red lantern is placed exactly on the center line of the canal, showing both up and down, as a danger signal, when the draw is closed against navigation.

### POWER-HOUSE.

The canal power-house is situated about the middle of the summit level, advantage being taken of the crossing of the Grease River to use it as a tail race. The power-house is combined with a waste weir and will be described further on under electrical installations. Some 720 HP. is generated for lighting and for operating gates and valves.

### GUARD GATES FOR LOCK NO. 4.

The summit level ends with a guard gate and lift lock. The guard gates are 1,000 ft. above the lock, Fig. 8, and are never opened until the lock gates are closed. To the south is a feed raceway 50 ft. wide on bottom, with 2 to 1 slopes. It is throttled by two large "Stoney" sluices, 20 ft. × 22 ft., which hoist up into a steel superstructure resembling a double gantry. The guard gate itself is 46 ft. wide—the width of a lock—and consists of two hollow quoin abutments with splay walls above and below, Fig. 9. A pair of gates exactly similar to lock gates revolve in the quoins and close against miter sills. The splay walls above and below are of concrete, and are made 10 ft. wide to form a roadway on the south side. Through these, arches of 15-ft. span are pierced to pass the feed water into the raceway and out of it. A foundation platform was first made of concrete 12 ft. wide and 2 ft. deep, and upon this the arches were built. These slabs and that under the guard gate and sluice rest directly on hard blue clay, and have given no trouble.

### LOCK NO. 4.

Between guard gate and lock the ordinary section of canal prism is resumed for about 300 ft. Splay walls, as usual, are placed above and below the lock to lead in vessels. A raceway to the south, Fig. 8, passes the feed water to the reaches below. It is 27 ft. wide on the bottom, with 2 to 1 slopes giving a transverse area at working level of 1,100 sq. ft. A regulating weir placed across the end of the raceway in line with the foot of the lock, governs the feed to the reaches below. This weir is a concrete dam faced with cut stone and pierced by two submerged arches, which are

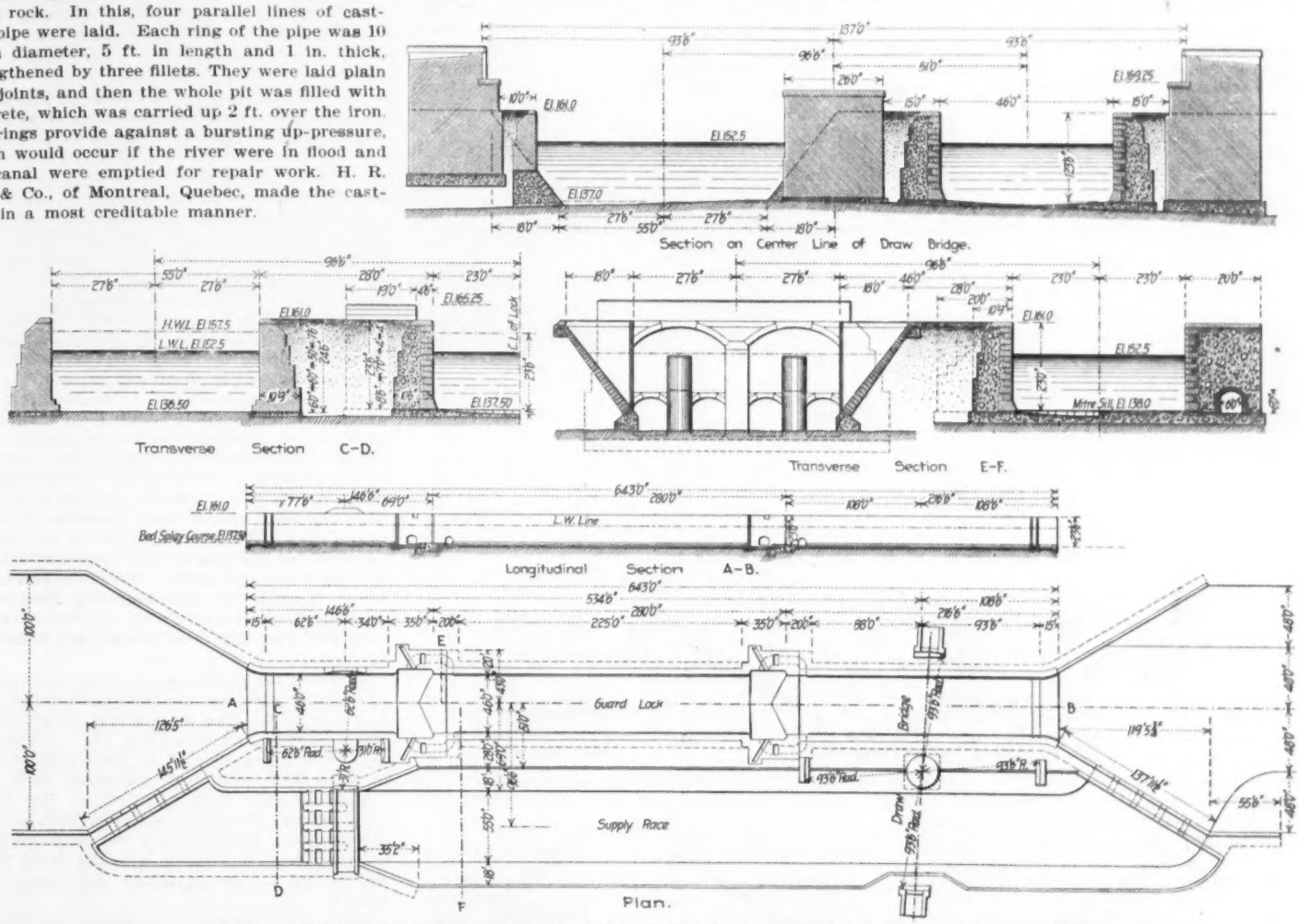


FIG. 4. DETAILS OF GUARD LOCKS AT CANAL ENTRANCE; SOULANGES CANAL WORKS, CANADA.

ROUGE.—The Rouge is passed under the prism in a similar manner to the Delisle, but only two lines of 10-ft. diameter pipe are used. The foundation was on boulder material underlying some 30 ft. of blue clay.

GREASE.—Only one line of 10-ft. pipe was required for the Grease River culvert; the foundation was on piles. An accident occurred during construction. Fig. 6 shows this pipe in place and partly covered with the concrete filling. The water, with which the pit was filled for protection against frost, burst out and its heavy ice covering settled down on top of the cast-iron tube, which had only been half concreted. Many rings were broken, but they were repaired in place with angle irons and bolts.

### DRAW BRIDGES.

Four bridges cross the summit level, all of similar design. There is no pivot pier in midchannel, but instead the pivot is placed in line with the south bank, and the whole width of the bottom, 100 ft., is free for navigation. A boat passing

closed by "Stoney" valves 9 ft. wide and 7 ft. high, Fig. 10. The face of the wall is buttressed and four blind arches widen the top sufficiently to give a 10-ft. roadway. Below this weir the water is turned into the canal again through the arches of the raceway bridge.

The lock itself is of concrete construction, only the face of the chamber above the lower reach water level being of cut stone. The lower sill is at elevation 125 (above sea) and the upper is at 137. On top of the sills 15 ft. of water is provided for 14-ft. navigation, so the lower reach working water level is (125 +15) El. 140 and the upper (137 + 15) El. 152. This would be a lift of 12 ft., but usually the summit level will be worked at El. 154 or 155, making the lift 14 or 15 ft. For the foundation of this lock 1,100 rock elm piles were driven 40 to 45 ft. into blue clay at 4-ft. centres under each lock wall and across the upper and lower ends. The tops were cut off and embedded in concrete, which was rammed about them. Between the walls the lock floor is a concrete slab 250 ft. long and 43½ ft. wide and fin-

ished to an invert 18 ins. thick along the centre and 3 ft. at the sides. The upper end of this floor fits against the circle of the breast wall and the lower end is finished with a line of cut stone blocks. The lower miter sill is carried on piles; it consists of a mass of concrete extending 8 ft. below the floor, which forms both an anchor block for holding down the sills and a cut off against leakage. Two I-beams are laid directly under each sill and through them pass seven bolts, 1½ ins. in diameter and 7 ft. long, the whole being buried in the mass of concrete. The ends of the anchor bolts are threaded and pass vertically through the 18 × 18-in. oak sills, which are held down by large nuts and washers. The upper miter sill is carried on a circular breast wall extending across between the lock walls and is anchored down in the same manner as the lower one.

The breast wall is a mass of concrete faced with heavy cut stone ashlar. It serves to take the ram of ascending boats, thus preventing their bows pushing open the miter of the upper gates from the lower side—a frequent source of accident. In front of the breast wall is another cross wall, which revets the end of the upper reach. It forms

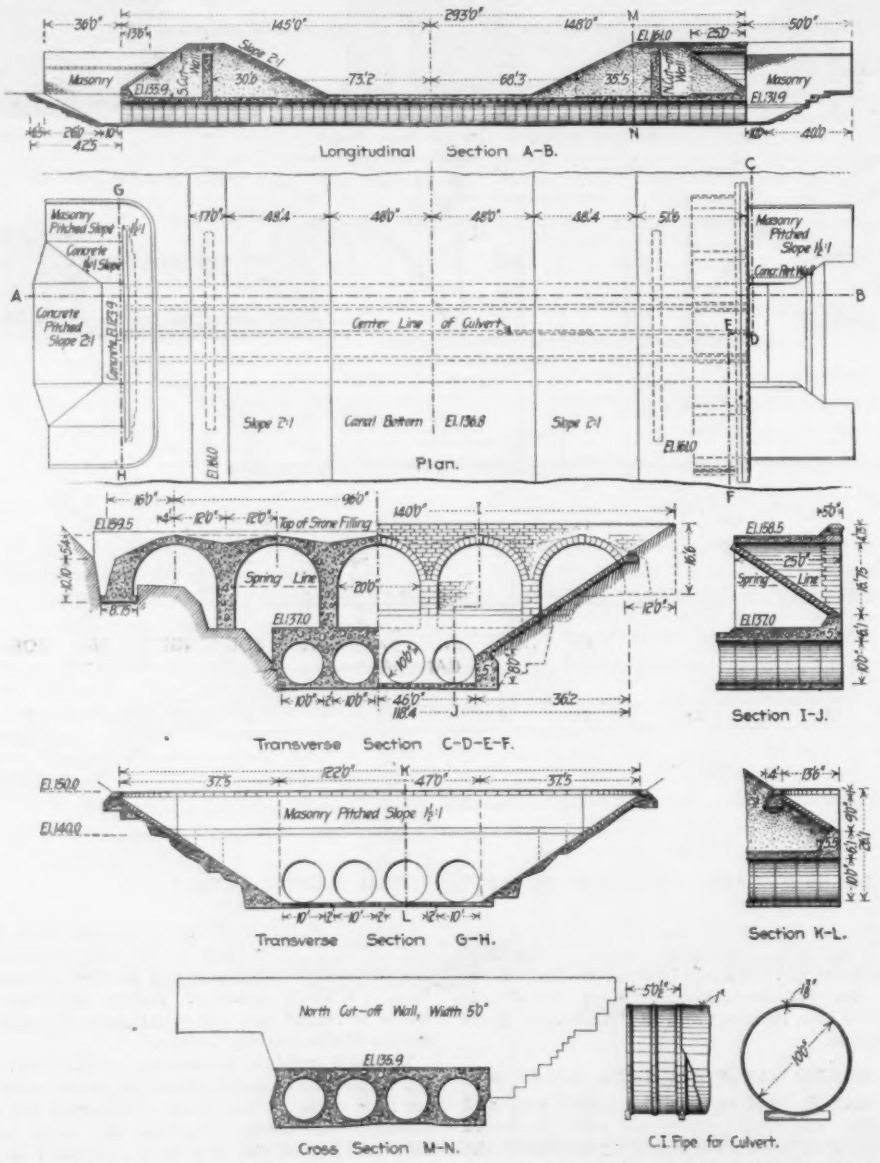


FIG. 5. DETAILS OF CULVERT FOR DELISLE RIVER; SOULANGES CANAL WORKS, CANADA.

with the breast wall a bay, 30 ft. across, and the full width of the lock, 46 ft. From this head well the longitudinal wall culverts are fed in filling the lock. The culverts are 6 ft. × 6 ft. with arched roof and are provided at each end with "Stoney" valves. These allow the water to flow into or out of the lock chamber, with which the culvert is connected by 30-in. pipes, ten on each side.

The method of construction was to lay the whole concrete foundation slab under the walls and across the ends. The floor of the head well, the floors of the culverts and the lower miter sill are all on the same level (El. 125). Upon this the molds for face and rear of walls and for sides of culverts were set up. The concrete was mixed by hand along the sides of the pit and wheeled in until the spring line of the culvert arch was reached. A trestle had then been completed through the lock chamber and two traveling derricks erected upon it. These swung in the concrete with skips. The posts of the trestle served to hold the chamber face molds, which were 14 ft. high. Above this height the lock wall was ashlar, the first course projecting 2 ins. and being rounded to form a rubbing course.

## REACH BELOW LOCK NO. 4.

Below Lock No. 4, a reach similar to the summit level extends for nearly 2½ miles. Half a mile below the lock there is a road bridge like those on the summit level. It is founded on hard blue clay and has given no trouble from settlement. All swing bridges are at right angles to the line of canal. The north bank, as on the summit level, is 50 ft. wide to allow space for a macadam road to replace the old river road cut off by the canal. The south bank is 15 ft. wide at an elevation of 3 ft. above water level with 2 to 1 slopes.

## BISSONETTE EMBANKMENT.

The chief feature of this level is its crossing of a ravine about 500 ft. long and 40 ft. deep below the "tow-path" elevation. The canal is carried across by an embankment containing 250,000 cu. yds., built of clay excavated from the prism. The full cross-section is maintained, viz.: 100 ft. bottom width and 2 to 1 slopes. The exterior slopes are also 2 to 1, making the base of bank nearly 500 ft. across. Under this fill a 30-in. cast iron pipe passes a small creek. The reach end

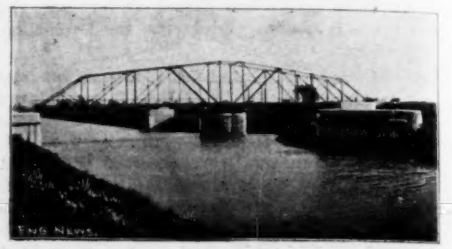

Fig. 7. View Showing Typical Highway Swing Bridge Crossing Canal; Soulanges Canal Works, Canada.

at the Cascades Locks. The water surface is constantly kept at elevation 140, giving 16 ft. of water, or 2 ft. under vessels drawing 14 ft.

## EARTH WORK.

The lower entrance of the canal is cut into a tongue of land separating the Ottawa River from the St. Lawrence River. This point is of Potsdam sandstone, but unfit for building masonry, though it was much used for concrete. For a distance up of 1,000 ft. it is denuded, then it is lost to sight under a 50-ft. clay bluff. The Potsdam continues fairly level for about eleven miles west when it overlaid by calciferous rock. From the general profile, Fig. 3, it will be seen that the clay surface rises abruptly at Cascades, then very gradually for about five miles, after which it continues at a general level only slightly above the surface of Lake St. Francis. The lower half of the canal is in hard brown clay overlying a compact blue clay. The next quarter is in a soft blue clay with only a scant covering of sandy brown clay. The upper quarter is in boulder. Over 200,000 cu. yds. of rock were excavated at the upper end and nearly 100,000 cu. yds. at the lower. Besides this there was over 7,000,000 cu. yds. of earth excavation of all kinds, varying from soft blue clay to quicksand, wet gravel and hard pan.

Generally the surface brown clay was removed by wheel scraper, and the front parts of the banks made up of it. The bottom was excavated by steam shovels and cars (Fig. 11). Three-yard cars of 3-ft. gage hauled by ten-ton locomotives on 30 to 56-lb. rails were extensively used.

Standard gage plant was used on the Onderdonk sections five miles in length. Sixteen miles of track were employed and the main line along the canal bank connecting with the Grand Trunk Ry. carried all the materials and supplies to Lock 4.

Earth from the steam excavators is often in large lumps which cannot be cut up and compacted into banks as the output is too rapid. Flooding the dumped clay with a sprinkling hose was found to be a successful means of meeting this difficulty. A demand for digesting apparatus would no doubt be met by the shovel manufacturers.

The rock excavation was done in the ordinary manner by steam drilling and derrick handling. All the rock at Cascades has been used up for concrete, etc., and other large amounts have been employed for bank lining along the canal.

The stone side slope protection amounts to 155,000 cu. yds.; it was generally dumped into the notch from carts, but some has been transported by scows, since opening the canal, and deposited from gang planks.

## CRIBWORK.

The only extensive use of timber was in submerged cribwork foundations for the upper and lower entrance piers. This was all made "closework," of 12 × 12-in. timber, mostly hemlock. The cribs are 25 ft. wide and about 16 ft. in height with two rows of longitudinals, and cross-

ties every 5 ft. They were generally built in 100-ft. lengths, floated to place and filled with stone or boulders from the excavation. Along the face a platform of 12 × 12-in. timber was laid just below water and a concrete dock wall built upon it. The wall and crib foundation was heavily backed with stone filling. Cast-iron mooring posts are employed throughout. They are cylinders 10 ins. in diameter and 1 in. thick set in cubes of concrete 5 ft. deep, from which they project 19 ins. Before setting each post is rammed full of concrete.

For each contract a bulk sum was bid for unwatering, which included pumping, making and removing dams, and removing ice and snow.

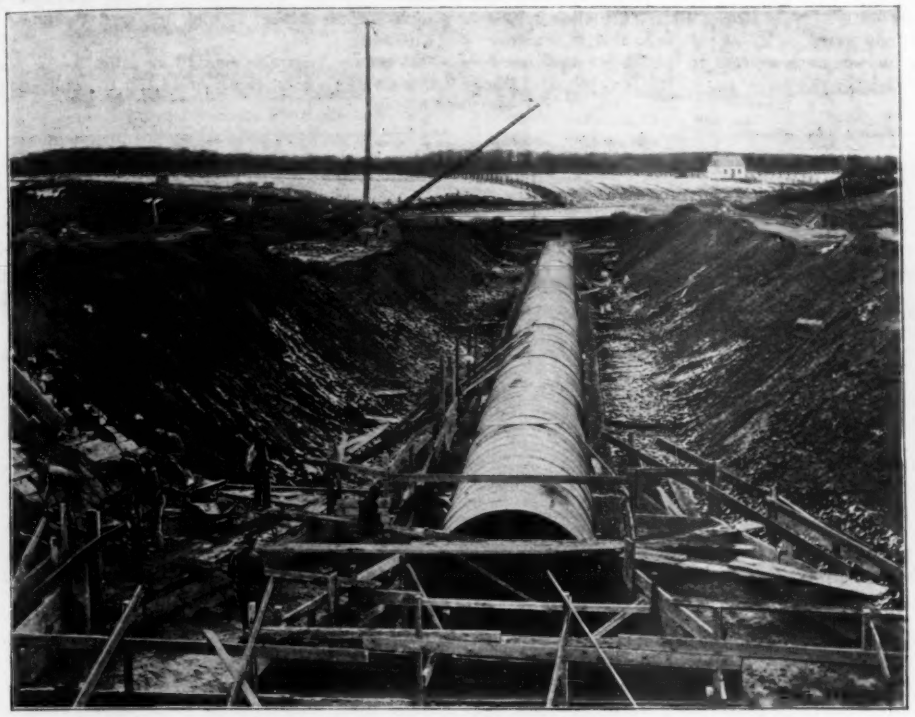

FIG. 6. VIEW OF SINGLE-PIPE CULVERT FOR GREASE RIVER DURING CONSTRUCTION; SOULANGES CANAL WORKS, CANADA.

## SLIDES.

The greatest difficulty encountered in construction was the slipping of the clay sides of the canal along about two miles of the summit level. Most trouble was experienced at the St. Emmanuel road crossing. Here an inch rod could be easily pushed down 80 ft. through blue clay fetching up on rock or hard material.

The canal is in 25-ft. cutting and for the north abutment of the road bridge, piles were driven down 40 ft. more below the bottom. A concrete foundation slab, level with canal bottom, was laid upon these piles about the beginning of November. A few days later 300 ft. in length of the north slope slid out over the foundation and half way across the cut. Next season this slip was excavated, and the north abutment—a concrete monolith of 1,200 cu. yds.—was built upon the foundation, which had not been injured. Between this abutment and the face of the old slip, about 100 ft. in width, all the blue clay was excavated to canal bottom and the space refilled with dry brown clay laid up in layers by wheel scrapers.

Toward the end of October, 1897, however, another sudden slip occurred at the same place completely filling the canal again. Fig. 12 shows the appearance of this slide. The abutment was forced out 30 ft. into the prism and canted over, bending the foundation piles like whips. It was not even cracked, however, and had to be blasted out piece by piece.

For over a mile this north canal slope has finally been flattened from a 2 to 1 slope to a 4 to 1 with a heavy stone toe.

The blue clay deposit constitutes a "mere bleue" or saturated clay lake, through which the canal, during construction, formed a deep drainage ditch. The subwater plane gradually sloped down to the canal bottom, draining in under the slope until its friction was destroyed and the mass slid forword settling down along vertical cleavage planes as it moved. The whole matter was aided by the fact that the blue clay beds, 3 ins. thick, seem to have dried after deposit and cracked like a mud beach. These vertical cracks allow the water to percolate down and create hydrostatic pressure. The surface covering being sandy along this section allowed storm water to enter more readily than lower down the canal where the brown clay covering is thicker and nearly impervious.

## SURVEY WORK.

In establishing the center line, posts 10 ins. in diameter and 20 ft. high were set at the intersection points of tangents and also along tangents at about three-mile intervals. A transit was interpolated between these poles and during ten years it has never been necessary to keep reference hubs The long curves of large radius required all calculations to be actually worked out as the difference between a 100-ft. chord and the curved arc became noticeable, and the tables could not be applied. The upper curve, three miles in length, was divided into halves and tangent poles set at the intersection of the tangents for each half.

For field work steel band chains and 1-in. gas pipe pickets were used. A 500-ft. chain did not prove itself of much value.

The ground surface for 300 ft. on each side of canal center line was accurately cross-sectioned, some 20,000 readings being taken. This work was greatly hastened by the use of two rods for each level. The right of way varies in width, but is generally 200 ft. on each side of the center line of the canal. About 950 acres were taken altogether, including farms bought for wasting ground.

The cross-sections were plotted on a natural scale of 10 ft. to an inch and bound in books, contract by contract. On the right-hand page was plotted the north half of two cross-sections and on the left the south halves, the middle of the book being the centre line. This generous spacing, though bulky, has proved to be very convenient for progress, estimates, etc.

Borings were taken every ten chains with a 2-in. auger attached to gas pipe. Numerous test pits were also dug, some being 40 ft. in depth. Generally 5 to 10 ft. of hard brown surface clay was found to overlie blue clay varying from the consistency of tough cheese to soft butter.

The preliminary hydrographic survey at the lower entrance was made by a fan of sounding lines radiating from a fixed point ashore and extending two or three miles out. A boat with sextant observer, sounding man and recorder aboard, was rowed out, keeping in range with the fixed hub and a movable back flag. Each sounding was fixed by measuring the angle between the range aft and a distant known side point. To plot, a line, parallel to the range line, is drawn through the distant side station and from this the sextant angles are laid off to intersect the range.

For close soundings a line of boards 4 ins. wide and hinged together in 10-ft. lengths was floated into the line and soundings made along it from a boat. Slight breezes deranged this long float, so it was only useful in calm water. Skeleton rafts, 200 ft. long and 25 ft. wide, were also used, the sounding man walking along the timbers which are fished together with plank and spikes and well cross-braced.

Sounding through the ice at Cascades was impracticable owing to anchor ice and "frazil." This is caused by the agitated water pouring through the Cascades Rapids being unable to crystalize though cooled far below 0°. C. In an instant of rest, however, articular crystals are suddenly

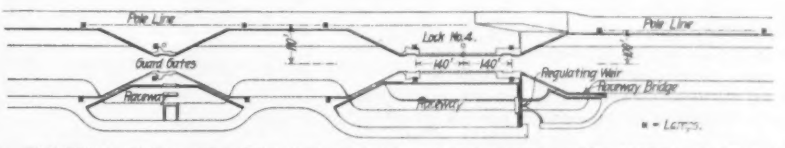


FIG. 8. DIAGRAM PLAN OF LOCK NO. 4 AND GUARD GATE; SOULANGES CANAL WORKS, CANADA.

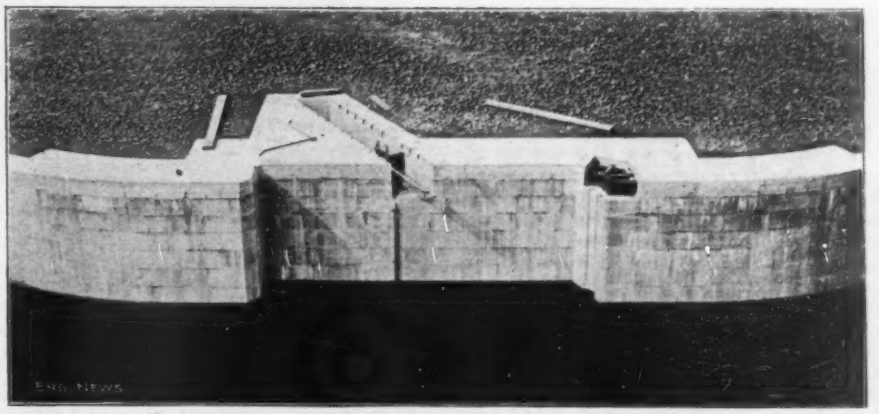

FIG. 9. VIEW OF GUARD GATE ABUTMENT, SHOWING GATE ANCHOR BOX AND OPERATING BAR; SOULANGES CANAL WORKS, CANADA.

formed. These drift down and accumulate in still water beneath the surface ice, forming immense masses resembling wet wool and eventually packing the river full to the bottom. Submerged bergs, several square miles in area, are thus formed, which choke the flow, and the water stands at various levels in isolated pools. Differences of 2 ft. in level were noted in holes cut only 50 ft apart, so no soundings could be done under such conditions. "Frazil" or "cinder" ice mixed with large cake ice has been observed 80 ft. in depth. Long lines of soundings were generally made by stretching steel wire with a cork float every 20 ft. between rafts anchored in exact positions.

The transit work included traverses of roads and the shore line of the St. Lawrence between the head and foot of the canal. All these were tied on to the center line forming closed traverses of about three miles in extent; the results have been very good. There was also a large triangulation of the vicinity.

The leveling has been very extensive as lines were run to Kingston, to Rouse's Point and to Montreal, thus connecting with sea level at New York and at Quebec. The results proved wonderfully correct, though no attempt at precise leveling was made, and there is the satisfaction of having elevations, which convey some meaning and may be compared with distant points and referred to in descriptions and reports. A photographic record has been kept of all the construction.

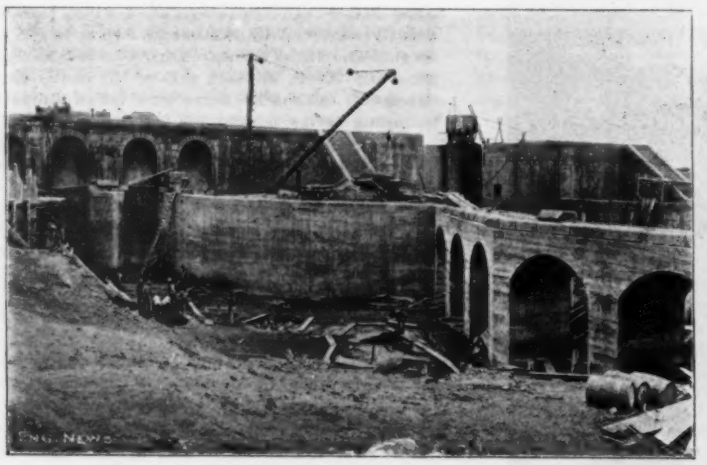

FIG. 10. VIEW SHOWING MASONRY OF REGULATING WEIR AND RACEWAY BRIDGE AT LOCK NO. 4; SOULANGES CANAL WORKS, CANADA.

FIG. 11. TYPICAL VIEW OF EXCAVATION IN EARTH; SOULANGES CANAL WORKS, CANADA.

## AUSTRALIAN ARTESIAN WELLS.

Statistics show that out of the 3,077,370 sq. miles which Australasia covers, 1,219,600 sq. miles have an annual rainfall under 10 ins.; in another 852,540 sq. miles this rainfall is only 10 to 20 ins per year; while in the central and southern part of the continent, over a very large area, the rainfall is under 5 ins.

Under these conditions the question of an additional water supply is an important one; and, though the existence of underground water in considerable quantities had been earnestly discussed for a long time, it was not until 1879 that doubt was set at rest by finding artesian well water at Kallara Run, at a depth of 140 ft. below the surface. Since 1884, the government has been searching for water and sinking wells; and in New South Wales alone the aggregate daily flow from underground water amounts to 78,000,000 gallons, not including large supplies pumped from sub-artesian wells.

Up to 1900, the government of New South Wales sunk 88 wells, 6 of which are still in progress, says Mr. Coghlan, the government statistician, in the eighth issue of his "Statistical Account of Australasia." Of the 82 completed wells, 56 are flowing wells, 18 yield supplies by pumping, and seven have been failures. The average depth of these wells is 1,648 ft.; but they range from 120 ft. to 4,086 ft. in depth. The last is on the road from Moree to Boggabilla, and it yields about 745,200 gallons per day. The largest flow comes from the Kenmore Bore, between Bourke and Hungerford; and this well, 1,539 ft. deep, yields 2,050,000 gallons daily. The Moree Bore furnishes 1,108,000 gallons daily, is 2,792 ft. deep, and is interesting as having been carried to this depth through formations of the same age as the Ipswich coal measures. The fact is thus demonstrated that water can be obtained in other than the lower cretaceous formation.

Of the 128 wells sunk by private enterprise, 16 were failures; but some of these wells flow to the extent of 4,000,000 gallons daily, and the aggregate flow is approximately 45,000,000 gallons daily. The total cost of the government wells of New South Wales, including actual boring, casing, carriage and incidental expenses, is £243,938, or an average of £1 16s. 1d. per lineal foot, or $8.66.

Up to June 30, 1898, 41 wells had been sunk in Queensland by the government, 11 by the Railway Department and 582 by private individuals. Of the first 16 wells were flowing; and of the latter 356 wells were successful. The aggregate daily flow from the government and private wells is 213,000,000 gallons. The deepest well is 4,860 ft., at Bothwell, on the Bimarah run; the average depth of wells in this state is about 1,177 ft. Much of this water is used for irrigation purposes, 5,229 acres being thus treated.

In South Australia, out of 87 wells sunk by the Water Department, only 33 were successful. The well at Strangways, and another at Coward, yield 1,200,000 gallons daily each; and the total daily supply for the whole colony is only 4,449,600 gallons, representing a cost in well sinking of £167,891.

Western Australia has 16 artesian wells, reaching an aggregate depth of 14,165 ft., and yielding in total 4,806,500 gallons daily. In addition to these three sub-artesian walls, aggregating 2,511 ft. in depth, yield a pumped supply of 531,700 gallons daily. The Province of Victoria has made several experimental borings since 1886, but has not yet met with any encouraging success; though artesian water was struck at Sale, in Gippsland as early as 1880.

The temperature of the water in the wells of New South Wales ranges from 80° to 139° F.; the temperature in the Queensland wells is as low as 70° at Bingara, and as high as 196° F. at Dagworth.

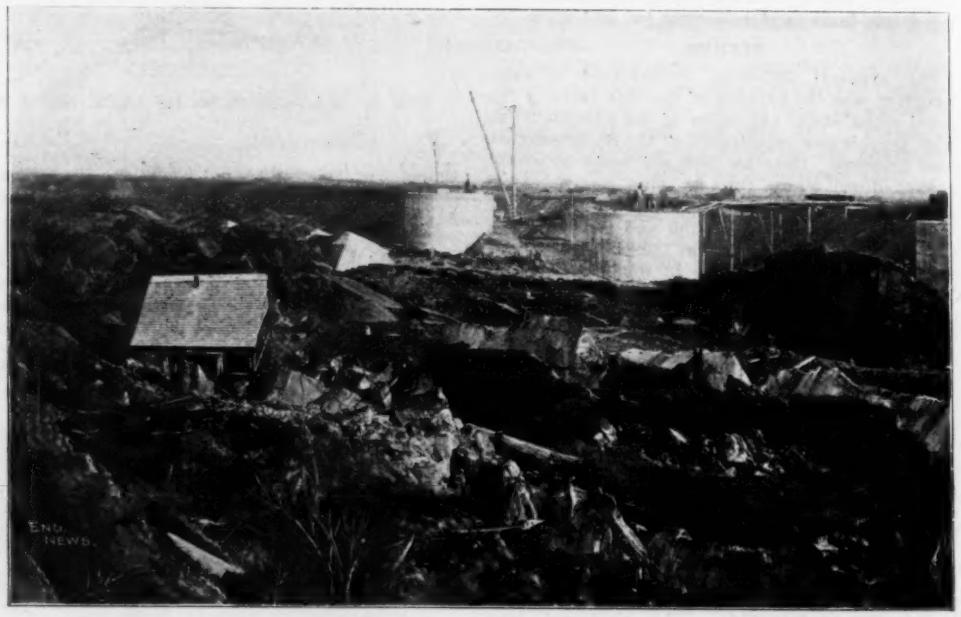

FIG. 12. VIEW SHOWING EARTH SLIP ON SUMMIT LEVEL; SOULANGES CANAL WORKS, CANADA.

THE WATER SUPPLY OF TOKIO, JAPAN, says London "Engineering," was originally derived from a canal and a system of wooden pipes, put in place about 200 years ago. The present city, with an actual population of about 1,200,000, has a thoroughly modern water supply taken from the River Tama. The system includes reservoirs, filtering basins and a cast-iron distributing system; the present available supply is sufficient for a population of 1,300,000, at about 30 U. S. gallons per head per day, and with comparatively slight modifications a population of 2,000,000 could be provided for.

## THE EFFECT OF WATER METERS ON WATER CONSUMPTION IN THE LARGER CITIES OF THE U. S.

By George I. Bailey, M. Am. Soc. C. E.*

Conditions arising in the operation of the water-works of the city of Albany made it desirable for its officers to have information concerning the water supply of other cities.

The conditions were, an enormously increased consumption of water during the winter, almost an even rate of consumption for each hour of the 24, and an insufficient pressure in high portions of the city, all of which created an urgent demand for furnishing greater quantities of water, which meant a general addition to our plant, or else methods for restricting waste.

The general conditions are not new, and as they either have occurred, or will occur, in almost every city, they are assumed to be of interest to water-works officials. All of these conditions sum up in the question of, whether it is cheaper and better for water takers to waste water or not to waste it. It is an easy matter to give reliable estimates of cost for increasing the plant, and for furnishing and placing water meters. There is a lack of information as to how well water meters will control the supply, their life, their operating cost, and their effect upon the water takers' pocketbook. Although there is an abundance of evidence as to what has occurred in especial cases and locations, we know of no general summary.

For our information we wrote to every city in the United States having a population of 25,000 people or over, by the census of 1900. We received replies from 136 of the 159 cities. Available information on quantity of water furnished daily was given by 134 cities, having an aggregate population of 17,650,000. Available information on receipts from water was given by 102 cities, having a total population of 15,814,000. In each case the population represents more than 20% of the total population of the United States. The locations of the cities are widespread, and therefore the averages are representative. The cities which refused information were generally those whose water supply was controlled by private companies.

We find the average per capita consumption in these American cities to be 137 gallons. The effect of placing water meters is as follows:

| Taps metered. | Consumption—Daily, per capita, gallons. | Per ct. of average. |
|---|---|---|
| Less than 10% | 153 | 112 |
| 10 to 25% | 110 | 80 |
| 25 to 50% | 104 | 76 |
| More than 50% | 62 | 45 |

In cities where the number of consumers was not given, we assumed that the total population was supplied. We understand that it is rare for a city to supply all its people with water, and to offset this over-estimate, we have taken into account that most cities have at least a partial supply received from pumps, and that the universal rule is to credit the full quantity of water calculated on plunger displacement without making any allowance for slip or leakage of pumps. The gaging of the Croton Aqueduct made by Mr. John R. Freeman, M. Am. Soc. C. E., for the Comptroller of the City of New York, shows an over statement of quantity delivered by gravity through that aqueduct, and this over statement we believe applies approximately to all such supplies. We believe, therefore, the over estimate of population is equalized by the over statement of quantity supplied.

Where the total number of taps was not given we assumed one tap to six persons. These assumptions and some misunderstanding of questions by different officials may make slight differences, but the numbers used are so large that they would not materially affect the results.

In all cases cities were asked to state the number of consumers. There is a decided difference of opinion among water-works officials as to what constitutes a consumer. In the northeastern and middle states a consumer is understood to be an individual. In most of the other cities a consumer is considered a collective number of individuals, either a family or colony, supplied from a single tap. As we did not understand exactly what was meant in the several cases, we adopted the method stated above.

In regard to cost, we find $2,25 to be the annual

*Superintendent Bureau of Water, Albany, N. Y.

TABLE I.—WATER CONSUMPTION, USE OF METERS AND RECEIPTS FOR WATER IN OVER ONE HUNDRED OF THE LARGEST CITIES OF THE UNITED STATES.†

(Compiled from Special Official Reports by George I. Bailey, M. Am. Soc. C. E., Superintendent of the Bureau of Water, Albany, N. Y.)

| Rank in popul'n. | Cities. | Population Census of 1900. | Population Supplied. | Consumption, galls. per day. Total. | Consumption, galls. per day. Per consumer. | Average annual receipts—Total. | Average annual receipts—Per consumer. | No. of taps. | Meters in use. | Taps metered, %. | Meters frnshd and set.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 87. | Akron, O. | 42,728 | 20,000 | ..... | 200 | Private. | .... | 4,276 | 400 | 9.35 | D | D |
| 40. | Albany, N. Y. | 94,151 | 95,000 | 18,100,000 | 191 | $292,000 | $3.07 | 16,500 | 2,030 | 12.30 | D | B |
| 113. | Allentown, Pa. | 35,416 | 37,000 | 4,357,000 | 118 | 61,800 | 1.70 | ..... | 17 | ..... | C | C |
| 96. | Altoona, Pa. | 38,975 | 37,900 | ..... | 95 | 68,000 | 1.79 | 8,496 | 225 | 2.64 | D | D |
| 43. | Atlanta, Ga. | 89,872 | 65,600 | 5,444,000 | 84 | 133,800 | 2.06 | 9,275 | 8,500 | 91.64 | C | C |
| 148. | Atlantic City, N. J. | 27,838 | 28,500 | ..... | 80 | 110,000 | 3.86 | 4,249 | 3,298 | 77.62 | D | D |
| 135. | Auburn, N. Y. | 30,345 | ..... | 4,500,000 | 148 | 75,000 | 2.47 | 5,000 | 400 | 8.00 | D | D |
| 6. | Baltimore, Md. | 500,000 | 576,000 | 56,000,000 | 97 | 950,000 | 1.65 | 110,000 | 1,607 | 1.46 | C | C |
| 150. | Bay City, Mich. | 27,628 | 17,000 | 3,000,000 | 177 | 45,000 | 2.65 | 2,200 | 826 | 37.54 | D | C |
| 124. | Bayonne, N. J. | 32,722 | ..... | 3,071,000 | 94 | 139,000 | 4.25 | 3,000 | 3,000 | 100 | C | C |
| 93. | Binghamton, N. Y. | 39,647 | ..... | 5,936,000 | 156 | 95,000 | 2.47 | 7,000 | 523 | 7.47 | B | D |
| 5. | Boston, Mass. | 560,900 | ..... | 80,000,000 | 143 | 2,233,000 | 3.98 | 81,000 | 4,455 | 5.50 | D | D |
| 54. | Bridgeport, Conn. | 70,996 | 70,000 | 16,500,000 | 236 | Private. | .... | 8,000 | 171 | 2.14 | D | D |
| 92. | Brockton, Mass. | 40,063 | 35,000 | 1,165,000 | 32 | 77,000 | 2.20 | 5,275 | 4,300 | 81.51 | C | C |
| 8. | Buffalo, N. Y. | 352,400 | 400,000 | 92,365,000 | 233 | 650,000 | 1.62 | 64,638 | 1,049 | 1.62 | .. | .. |
| 133. | Butte, Mont. | 30,470 | 45,000 | ..... | 100 | Private. | .... | 5,531 | 341 | 6.17 | D | D |
| 41. | Cambridge, Mass. | 91,886 | ..... | ..... | 79 | 324,000 | 3.53 | 14,207 | 860 | 6.05 | D | D |
| 52. | Camden, N. J. | 75,935 | 50,000 | 14,000,000 | 280 | 161,000 | 3.22 | 14,060 | 197 | 1.41 | D | D |
| 132. | Canton, O. | 30,667 | ..... | 3,750,000 | 122 | 36,000 | 1.17 | 4,300 | 45 | 1.05 | B | C |
| 157. | Cedar Rapids, Ia. | 25,656 | ..... | 3,000,000 | 117 | Private. | .... | 2,800 | 60 | 2.14 | D | C |
| 68. | Charleston, S. C. | 55,807 | ..... | 1,800,000 | 32 | Private. | .... | 1,750 | 20 | 1.14 | C | C |
| 117. | Chelsea, Mass. | 34,072 | ..... | 3,000,000 | 88 | 88,000 | 2.58 | 6,146 | 118 | 1.92 | D | D |
| 2. | Chicago, Ill. | 1,698,600 | ..... | 323,000,000 | 190 | 3,250,000 | 1.91 | 200,000 | 6,500 | 3.25 | C | C |
| 10. | Cincinnati, O. | 325,900 | ..... | 39,600,000 | 121 | 764,000 | 2.34 | 36,000 | 2,745 | 7.63 | C | C |
| 7. | Cleveland, O. | 381,800 | 420,000 | 66,900,000 | 159 | 766,000 | 1.82 | 63,632 | 3,143 | 4.94 | B | B |
| 28. | Columbus, O. | 125,560 | 100,000 | 223,000,000 | 230 | 165,000 | 1.65 | 14,608 | 4,960 | 33.95 | C | C |
| 156. | Council Bluffs, Ia. | 25,802 | ..... | 2,000,000 | 78 | Private. | .... | 2,761 | 557 | 20.17 | B | B |
| 86. | Covington, Ky. | 42,938 | ..... | 4,500,000 | 58 | 75,000 | 1.75 | 5,300 | 4,150 | 78.30 | D | D |
| 114. | Davenport, Ia. | 35,254 | 20,000 | 3,000,000 | 150 | Private. | .... | 4,000 | 1,500 | 37.50 | D | D |
| 45. | Dayton, O. | 85,333 | ..... | 5,300,000 | 62 | 133,000 | 1.56 | 12,000 | 5,600 | 46.67 | D | B |
| 25. | Denver, Colo. | 133,859 | 100,000 | ..... | 300 | Private. | .... | 23,549 | 282 | 1.19 | C | C |
| 59. | Des Moines, Ia. | 62,139 | ..... | 3,000,000 | 48 | Private. | .... | 7,499 | 4,289 | 57.19 | D | C |
| 14. | Detroit, Mich. | 285,700 | 306,055 | 44,800,000 | 146 | 465,000 | 1.52 | 55,340 | 5,555 | 10.04 | D | D |
| 107. | Dubuque, Ia. | 36,297 | ..... | 2,500,000 | 69 | 74,000 | 2.04 | 1,980 | 125 | 6.31 | C | C |
| 72. | Duluth, Minn. | 52,969 | 15,000 | 4,100,000 | 273 | 133,000 | 8.87 | 2,795 | 1,261 | 45.11 | C | C |
| 158. | Easton, Pa. | 25,238 | 25,000 | 2,000,000 | 80 | ..... | .... | 2,200 | 100 | 4.55 | D | D |
| 112. | Elmira, N. Y. | 35,672 | 20,000 | 4,500,000 | 225 | Private. | .... | 4,000 | 612 | 15.30 | D | D |
| 73. | Erie, Pa. | 52,733 | ..... | 7,458,000 | 142 | 139,000 | 2.64 | 11,163 | 266 | 2.38 | D | D |
| 64. | Evansville, Ind. | 59,007 | ..... | 8,000,000 | 136 | 76,500 | 1.30 | 5,367 | 12 | 0.21 | D | D |
| 33. | Fall River, Mass. | 104,863 | 104,500 | 3,805,000 | 36 | 168,000 | 1.61 | 6,943 | 6,544 | 94.25 | C | C |
| 128. | Fitchburg, Mass. | 31,531 | 25,000 | 3,000,000 | 120 | 68,500 | 2.74 | 4,437 | 2,427 | 54.70 | B | B |
| 83. | Fort Wayne, Ind. | 45,115 | ..... | 3,500,000 | 78 | 55,000 | 1.22 | 7,804 | 1,400 | 17.94 | C | C |
| 151. | Fort Worth, Tex. | 26,688 | 30,000 | 3,000,000 | 100 | 84,266 | 2.81 | 3,209 | 247 | 7.75 | D | B |
| 153. | Gloucester, Mass. | 26,121 | ..... | 950,000 | 36 | 76,000 | 2.91 | 2,817 | 56 | 1.99 | D | C |
| 44. | Grand Rapids, Mich. | 87,565 | ..... | 13,693,000 | 156 | 125,946 | 1.44 | 8,901 | 1,193 | 13.40 | ? | B |
| 77. | Harrisburg, Pa. | 50,167 | 57,000 | 8,202,500 | 144 | 115,800 | 2.03 | 12,000 | 4,278 | 35.65 | B | C |
| 49. | Hartford, Conn. | 79,850 | 80,000 | 8,500,000 | 106 | 270,000 | 3.12 | 9,351 | 2,550 | 27.27 | D | D |
| 104. | Haverhill, Mass. | 37,175 | 38,000 | ..... | 95 | 96,400 | 3.01 | 5,300 | 550 | 10.38 | D | C |
| 82. | Holyoke, Mass. | 45,712 | 45,700 | ..... | .. | 90,042 | 1.97 | 3,610 | 210 | 5.82 | C | D |
| 21. | Indianapolis, Ind. | 169,164 | ..... | 13,400,000 | 79 | 325,000 | 1.92 | 10,046 | 600 | 5.97 | D | C |
| 159. | *Jackson, Mich. | 25,180 | ..... | ..... | 100 | 30,000 | 1.19 | 3,300 | 400 | 12.12 | D | D |
| 142. | Jacksonville, Fla. | 28,429 | 20,000 | 2,136,000 | 107 | 53,649 | 2.68 | 2,335 | 1,154 | 49.42 | D | D |
| 17. | Jersey City, N. J. | 206,433 | 200,000 | 32,020,000 | 160 | 838,000 | 4.19 | 25,000 | 500 | 2.00 | D | D |
| 111. | Johnstown, Pa. | 35,936 | 33,000 | 4,750,000 | 144 | Private. | .... | 4,100 | 40 | 0.98 | D | D |
| 137. | Joliet, Ill. | 29,353 | ..... | 3,000,000 | 102 | ..... | .... | 2,500 | 300 | 1.20 | C | C |
| 22. | Kansas City, Mo. | 163,752 | ..... | ..... | 62 | 420,000 | 2.56 | 13,000 | 5,200 | 40.00 | C | C |
| 76. | Kansas City, Kan. | 51,418 | ..... | 4,301,000 | 84 | Private. | .... | 2,370 | 750 | 31.65 | C | C |
| 125. | Knoxville, Tenn. | 32,637 | 23,400 | 2,800,000 | 120 | Private. | .... | 4,250 | 380 | 8.94 | B | B |
| 140. | La Crosse, Wis. | 28,895 | 29,000 | 5,585,000 | 193 | 33,150 | 1.14 | 3,300 | 40 | 1.21 | C | C |
| 90. | Lancaster, Pa. | 41,459 | ..... | 6,000,000 | 145 | 103,000 | 2.48 | 6,000 | 500 | 8.33 | B | B |
| 57. | Lawrence, Mass. | 62,559 | 57,200 | 3,204,000 | 56 | 103,600 | 1.81 | 5,926 | 4,386 | 74.01 | C | C |
| 152. | Lexington, Ky. | 26,369 | ..... | 1,250,000 | 47 | Private. | .... | 1,500 | 1,482 | 99.47 | D | C |
| 91. | Lincoln, Neb. | 40,169 | 25,000 | 2,000,000 | 80 | 40,000 | 1.00 | 3,550 | 2,000 | 56.34 | C | C |
| 36. | Los Angeles, Cal. | 102,479 | 90,000 | 17,000,000 | 189 | Private. | .... | 22,000 | 600 | 2.72 | B | B |
| 18. | Louisville, Ky. | 204,731 | 160,000 | ..... | 100 | 557,000 | 3.48 | 20,755 | 1,560 | 7.52 | D | D |
| 39. | Lowell, Mass. | 94,969 | 94,000 | 8,000,000 | 85 | 202,000 | 2.15 | 10,634 | 5,586 | 52.53 | C | C |
| 55. | Lynn, Mass. | 68,513 | 73,000 | 4,600,000 | 64 | 210,000 | 2.88 | 12,577 | 2,500 | 19.88 | B | B |
| 120. | Malden, Mass. | 33,664 | ..... | 1,700,000 | 50 | 112,000 | 3.33 | 6,426 | 2,935 | 45.67 | D | D |
| 65. | Manchester, N. H. | 56,987 | ..... | 3,500,000 | 61 | 138,000 | 2.42 | 5,500 | 3,700 | 67.27 | D | D |
| 115. | McKeesport, Pa. | 34,227 | ..... | 2,500,000 | 73 | 50,000 | 1.46 | 3,833 | 754 | 19.67 | B | C |
| 37. | Memphis, Tenn. | 102,320 | 80,000 | 10,000,000 | 125 | Private. | .... | 9,600 | 800 | 8.28 | D | D |
| 15. | Milwaukee, Wis. | 285,300 | 300,000 | 24,000,000 | 80 | 430,000 | 1.43 | 41,485 | 28,039 | 67.59 | C | C |
| 19. | Minneapolis, Minn. | 202,718 | ..... | 18,813,000 | 93 | 225,000 | 1.11 | 18,800 | 5,175 | 27.53 | B | C |
| 98. | Mobile, Ala. | 38,469 | 19,500 | 2,800,000 | 144 | 36,300 | 1.86 | 3,890 | 31 | 0.80 | D | D |
| 47. | Nashville, Tenn. | 80,865 | ..... | 11,300,000 | 140 | 140,000 | 1.73 | 7,720 | 3,200 | 41.45 | B | B |
| 16. | Newark, N. J. | 246,070 | 255,000 | 24,000,000 | 94 | 600,300 | 2.71 | 33,500 | 7,342 | 21.92 | B | B |
| 58. | New Bedford, Mass. | 62,442 | 55,000 | 6,320,000 | 115 | 181,600 | 3.30 | 9,280 | 1,429 | 15.40 | B | B |
| 155. | New Britain, Conn. | 25,908 | 25,000 | ..... | 150 | 56,400 | 2.26 | 3,259 | 180 | 5.52 | C | C |
| 31. | New Haven, Conn. | 108,027 | ..... | ..... | 150 | Private. | .... | 14,500 | 375 | 2.58 | D | D |
| 13. | New Orleans, La. | 287,100 | ..... | 13,820,000 | 48 | Private. | .... | ..... | ..... | ..... | C | C |
| 144. | Newport, Ky. | 28,301 | ..... | 2,000,000 | 71 | 55,000 | 1.94 | 5,000 | 470 | 9.40 | C | C |
| 122. | Newton, Mass. | 33,587 | 32,800 | 2,086,000 | 64 | 131,000 | 3.99 | 7,087 | 6,001 | 84.68 | C | D |
| 1. | New York, N. Y. | 3,437,200 | ..... | 400,000,000 | 116 | 6,200,000 | 1.80 | ..... | 44,000 | ..... | C | C |
| 80. | Norfolk, Va. | 46,624 | 40,000 | 5,250,000 | 131 | 115,000 | 2.88 | 8,500 | 178 | 2.09 | C | C |
| 56. | Oakland, Cal. | 66,960 | 80,000 | 12,500,000 | 156 | 357,000 | 4.46 | 16,900 | 1,130 | 6.69 | D | D |
| 35. | Omaha, Neb. | 102,555 | ..... | 18,000,000 | 176 | Private. | .... | 11,000 | 3,800 | 34.55 | C | C |
| 145. | Oshkosh, Wis. | 28,284 | ..... | 2,500,000 | 88 | Private. | .... | 1,773 | 51 | 2.88 | C | C |
| 149. | Passaic, N. J. | 27,777 | ..... | 2,500,000 | 90 | Private. | .... | 2,900 | 929 | 32.03 | D | D |
| 32. | Paterson, N. J. | 105,171 | 98,000 | 12,600,000 | 129 | Private. | .... | 11,108 | 2,299 | 20.71 | D | D |
| 95. | Pawtucket, R. I. | 39,231 | 80,000 | 6,524,000 | 82 | 193,000 | 2.41 | 8,293 | 6,369 | 76.80 | B | B |
| 67. | Peoria, Ill. | 56,100 | ..... | 3,500,000 | 62 | Private. | .... | 6,058 | 418 | 6.90 | D | D |
| 3. | Philadelphia, Pa. | 1,293,700 | 1,254,000 | 287,188,000 | 229 | 3,047,900 | 2.43 | 250,000 | 1,275 | 0.51 | D | D |
| 11. | Pittsburg, Pa. | 321,600 | 234,000 | 54,000,000 | 231 | 806,000 | 3.44 | 33,084 | 200 | 0.60 | C | C |
| 42. | Portland, Ore. | 90,426 | 90,000 | 18,000,000 | 200 | 286,000 | 3.18 | 12,447 | 509 | 4.09 | D | D |
| 20. | Providence, R. I. | 175,597 | 187,300 | 10,130,000 | 54 | 577,587 | 3.08 | 21,566 | 17,813 | 82.60 | C | D |
| 147. | Pueblo, Colo. | 28,157 | 15,000 | 4,000,000 | 267 | 62,500 | 4.17 | 3,400 | 30 | 0.88 | D | D |
| 108. | Quincy, Ill. | 36,252 | ..... | 1,650,000 | 46 | Private. | .... | 2,700 | 1,300 | 48.15 | D | C |
| 139. | Racine, Wis. | 29,102 | ..... | 1,360,000 | 47 | Private. | .... | 4,916 | 1,200 | 24.41 | B | C |
| 50. | Reading, Pa. | 78,961 | 77,900 | 7,180,000 | 92 | 161,100 | 2.07 | 15,885 | 636 | 4.00 | B | C |
| 46. | Richmond, Va. | 85,050 | ..... | 10,048,000 | 160 | 140,000 | 1.65 | 14,781 | 4,500 | 30.44 | B | D |
| 24. | Rochester, N. Y. | 162,608 | ..... | 13,500,000 | 83 | 400,000 | .... | 34,549 | 8,752 | 25.33 | C | C |
| 130. | Rockford, Ill. | 31,051 | 22,000 | 2,600,000 | 118 | 38,900 | 1.74 | 3,373 | 270 | 8.00 | D | D |
| 89. | Saginaw, Mich. | 42,345 | 28,000 | 7,500,000 | 268 | 45,000 | 1.61 | 3,500 | 300 | 8.57 | D | D |
| 4. | St. Louis, Mo. | 575,200 | 400,000 | 63,530,000 | 159 | 1,483,000 | 3.71 | 65,688 | 4,133 | 6.29 | B | B |
| 23. | St. Paul, Minn. | 163,065 | 125,000 | 8,337,000 | 67 | 346,000 | 2.77 | 17,093 | 4,812 | 28.15 | B | C |
| 110. | Salem, Mass. | 35,956 | 35,700 | ..... | 70 | 80,000 | 2.24 | 6,400 | 180 | 2.81 | D | D |
| 70. | Salt Lake City, Utah. | 53,531 | 55,000 | 12,000,000 | 218 | 100,000 | 1.82 | 12,000 | 145 | 1.21 | D | D |
| 71. | San Antonio, Tex. | 53,321 | ..... | 8,500,000 | 159 | Private. | .... | 9,100 | 100 | 1.10 | B | B |
| 9. | San Francisco, Cal. | 342,800 | ..... | 25,000,000 | 73 | Private. | .... | 43,000 | 9,900 | 23.02 | D | D |
| 69. | Savannah, Ga. | 54,244 | 55,000 | 6,000,000 | 109 | 80,000 | 1.45 | 8,000 | 45 | 0.56 | C | C |
| 127. | Schenectady, N. Y. | 31,682 | 27,000 | 6,000,000 | 222 | 75,000 | 2.78 | 7,000 | 20 | 0.29 | D | D |
| 123. | Sioux City, Ia. | 33,111 | ..... | 1,427,000 | 43 | 43,600 | 1.32 | 3,000 | 1,525 | 50.83 | B | C |
| 48. | Seattle, Wash. | 80,671 | 60,000 | 8,500,000 | 142 | 200,473 | 3.34 | 6,181 | 800 | 12.94 | D | D |
| 105. | Spokane, Wash. | 36,848 | 32,000 | 7,925,000 | 248 | 157,500 | 4.92 | 5,000 | 165 | 3.30 | D | C |
| 61. | Somerville, Mass. | 61,643 | 62,000 | ..... | 88 | 210,000 | 3.39 | 10,000 | 200 | 2.00 | D | D |
| 60. | Springfield, Mass. | 62,059 | 48,200 | 5,471,500 | 113 | 243,700 | 5.06 | 9,764 | 3,122 | 31.97 | C | C |
| 101. | Springfield, O. | 38,253 | 33,000 | 3,000,000 | 91 | 43,000 | 1.30 | 4,200 | 200 | 4.76 | B | D |
| 116. | Springfield, Ill. | 34,159 | 18,000 | 4,000,000 | 222 | 67,000 | 3.72 | 3,000 | 230 | 7.67 | C | C |
| 129. | Superior, Wis. | 31,091 | ..... | 2,000,000 | 64 | Private. | .... | 1,800 | 140 | 7.77 | C | C |
| 30. | Syracuse, N. Y. | 108,374 | ..... | 11,000,000 | 102 | 273,000 | 2.52 | 17,000 | 8,037 | 47.28 | C | C |
| 103. | Tacoma, Wash. | 37,714 | 40,000 | 4,000,000 | 100 | 95,000 | 2.37 | 4,500 | 500 | 11.11 | D | D |
| 131. | Taunton, Mass. | 31,036 | 26,100 | 1,620,000 | 62 | 60,600 | 2.32 | 4,502 | 1,832 | 40.69 | C | D |
| 106. | Terre Haute, Ind. | 36,673 | ..... | 3,500,000 | 95 | Private. | .... | 4,265 | 285 | 6.68 | D | D |
| 26. | Toledo, O. | 131,822 | 68,384 | 7,750,000 | 119 | 140,000 | 2.14 | 11,888 | 5,975 | 50.26 | C | C |

TABLE I.—(Continued.)

| Rank in popul'n. | Cities. | Population Census of 1900. | Population Supplied. | Consumption, galls. per day. Total. | Consumption, galls. per day. Per consumer. | Average annual receipts. Total. | Average annual receipts. Per consumer. | No. of taps. | Meters in use. | Taps metered, %. | Meters frnshd and set.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 121. | Topeka, Kan. | 33,608 | ..... | 1,900,000 | 56 | Private. | .... | 2,900 | 550 | 18.97 | B B |
| 53. | Trenton, N. J. | 73,305 | 71,610 | 7,090,000 | 99 | 116,700 | 1.63 | ..... | 190 | ..... | D D |
| 62. | Troy, N. Y. | 60,651 | 58,000 | 10,600,000 | 183 | 104,500 | 1.80 | 7,500 | 314 | 4.19 | D C |
| 66. | Utica, N. Y. | 56,383 | ..... | 3,000,000 | 53 | Private. | .... | 7,064 | 6,838 | 96.80 | C C |
| 81. | Waterbury, Conn. | 45,859 | ..... | 6,000,000 | 131 | 115,500 | 2.51 | 4,899 | 486 | 9.92 | D D |
| 12. | Washington, D. C. | 287,700 | 270,000 | 50,000,000 | 185 | 350,000 | 1.30 | 45,000 | 1,200 | 2.67 | C C |
| 97. | Wheeling, W. Va. | 38,878 | ..... | 9,500,000 | 244 | 100,000 | 2.52 | ..... | 6 | ..... | D D |
| 51. | Wilmington, Del. | 76,508 | 76,500 | 6,930,000 | 90 | 162,300 | 2.12 | 15,000 | 640 | 4.27 | D D |
| 141. | Williamsport, Pa. | 28,757 | 26,000 | 4,500,000 | 173 | Private. | .... | 4,371 | 85 | 1.94 | D D |
| 146. | Woonsocket, R. I. | 28,204 | 32,000 | 933,000 | 29 | 72,800 | 2.28 | 2,347 | 2,136 | 91.01 | D D |
| 29. | Worcester, Mass. | 118,421 | 113,000 | 7,920,000 | 70 | 262,175 | 2.32 | 13,292 | 12,536 | 94.31 | C C |
| 79. | Yonkers, N. Y. | 47,931 | 45,000 | 3,627,000 | 81 | 147,944 | 3.29 | 4,968 | 4,852 | 97.67 | C C |
| 119. | York, Pa. | 33,708 | 36,000 | 2,850,000 | 79 | 93,000 | 2.58 | 8,300 | 275 | 3.31 | D D |

†The average per capita, consumption and receipts, are based on the population supplied, where reported; otherwise, on the population by the census of 1900.
*First column is for meters furnished by (D) department or (C) consumers; second column is for meters set by (D) department, (C) consumers, or (B) both.

per capita cost for water in all cities, indicating no difference, in dollars alone, to the water consumer for whatever method of charge is adopted. This is surprising, especially as it follows out in each of the metered percentage groups, and it would almost appear to be simply a coincidence. It may be explained that as the general use of water meters is comparatively recent in American cities, and that as the works were installed and the water debt incurred before the use of meters, that a sufficient time has not elapsed for them to have had their full effect on the water rates. If it is a coincidence, it shows conclusively that meter charges do not, as claimed, increase the cost to consumers.

A summary and averages of the detailed figures given in Table I. are presented in Table II., classified in accordance with the percentage of taps metered.

The results obtained are general, apply to no especial city or location, and their only purpose is to afford figures for ready comparison, and to identify the thing we have all heard of and never have seen, viz., the per capita consumption of water in American cities.

There is one result that stands forth preeminently, viz., that the average per capita consumption is twice as great as it should reasonably be, and that cities which are now in distress from danger of a water famine, and are consequently in search of additional supplies, can, by applying proper methods of conservation to their present supplies, more quickly and cheaply relieve themselves from their distresses, and by so doing have an abundant and adequate supply of water for twice as many inhabitants as they now have.

## CONCRETE CONDUIT CONSTRUCTION.

The city of Bloomington, Ill., is to have two competitive systems of heating by distribution from a central plant. It already has in operation a hot-water heating plant on the Yaryan system, and the Consumers' Heat & Electric Co. is now putting in a plant for heating buildings, etc., by means of the exhaust steam from its power station. To carry the pipes and the electric wires this company has adopted a novel form of concrete conduit or subway construction, which is illustrated in the accompanying cuts. As shown by the cross-section in Fig. 1, it consists essentially of a floor and side walls of concrete, with two lines of hollow tile electrical conduit embedded in each of the side walls. The space between the walls forms the pipe subway, and is covered by segmental arch plates of Monier steel-concrete construction, resting upon skewbacks formed in the upper corners of the walls.

In each wall is a line of six-duct vitrified clay salt-glazed conduit laid on its narrow side, and a superimposed line of four-duct conduit, all being laid with broken joints and surrounded with Portland cement concrete. This makes a system of ten electric ducts on each side of the central pipe duct. One side is intended for telephone and telegraph wires, and the other for electric light and power wires. The 20 electrical ducts are 3¼ ins. square in the clear. The pipe subway is 36 ins. wide, with a height of 30 ins. at the center, and 25 ins. at the sides. The entire width of the structure is 5 ft. 4 ins. The pipe subway will contain one 12-in. exhaust steam main, one 6-in. live steam main, and two 4-in. return pipes. These are all insulated with magnesia pipe covering and provided with expansion joints, roller bearings, etc.

The vitrified clay conduit is of the usual multiple-duct form, being in lengths of 3 ft., and alinement being secured by steel dowel pin-connections in the joints. The joints, though very close, are wrapped with burlap as a precaution against the entrance of cement mortar from the concrete. The

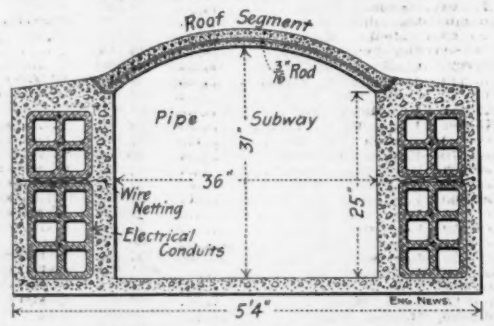


Fig. 1. Cross-Section of Pipe and Electric Wire Subway for the Consumers' Heat & Electric Co., Bloomington, Ill.

two lines of conduit in each side are separated by a thin coat of cement mortar in which is embedded a net of wire mesh that serves as a tie for the thin inner and outer vertical sections of concrete. This tie is considered hardly necessary, but is inserted to ensure ample strength. No dependence was placed upon the adhesion of the concrete to the clay tile, although a bond developed to an unexpected degree of strength. There are only 3.25 cu. ft. of concrete per lin. ft. of subway, exclusive of the roof. The concrete was mixed in proportions of 1 part Portland cement, 3 parts torpedo sand, and 5 parts crushed limestone. A hand-power drum mixing machine was first used, but was afterwards discarded for hand labor, the volume of concrete being so small in proportion to the entire work that there was no economy found in the use of the mixer. During very cold weather the cement, sand and stone were heated, and a small proportion of salt was mixed with the water.

One of the most striking features of the subway is the roof of Monier construction, which consists of arch plates with a clear span of 3 ft. and a rise of 6 ins. These plates are 2 ins. thick, with curved 3-16-in. steel rods embedded in the cement mortar, which is composed of 1 part Vulcanite cement and 3 parts torpedo sand. As the work was done during freezing weather the Monier plates were made under cover in a warehouse and transported to the location of the work when needed. They were easily handled and set in place by two men. By this method no centering was needed in the trench, and it was possible to place the backfilling immediately after the placing of the arch plate. The absence of centering for the tunnel roof greatly facilitated the progress of the work. Disregarding the element of time saved, the small space left between the steam pipes and the roof would have made the use of centering for ordinary construction a matter of difficulty and expense. Fig. 2 is a view of part of the completed subway, and Fig. 3 shows some of the roof segments delivered and ready for use.

The total length of the conduit will, when completed, be approximately 5,000 ft., traversing the central portions of Bloomington, and about 1,300 ft. have already been laid. The engineer in charge is Mr. Chas. G. Armstrong, 1503 Fisher Building, Chicago. The contractors are Hoeffer & Co., 315 Chamber of Commerce Building, Chicago; Mr. A. C. Warren is manager of this firm.

TABLE II.—Population, Water Consumption and Receipts for Water, Summarized and Averaged in Accordance with Percentage of Taps Metered.*

| | No. of cities. | Population.* | Consumption, gallons. Total, daily. | Consumption, gallons. Av. per consumer. | No. of cities. | Receipts. Population. | Receipts. Total. | Receipts. Av. per consumer. |
|---|---|---|---|---|---|---|---|---|
| 0 to 10% taps metered | 71 | 12,713,866 | 1,947,378,000 | 153 | 53 | 11,802,154 | $26,432,316 | $2.24 |
| 10 " 25% " " | 18 | 1,657,454 | 182,991,000 | 110 | 12 | 1,108,142 | 2,491,719 | 2.25 |
| 25 " 50% " " | 22 | 1,686,635 | 175,632,000 | 104 | 17 | 1,448,633 | 3,255,149 | 2.25 |
| 50 "100% " " | 23 | 1,600,333 | 109,616,000 | 62 | 20 | 1,455,442 | 3,253,606 | 2.24 |
| Totals and averages | 134 | 17,658,288 | 2,415,617,000 | 137 | 102 | 15,814,371 | $35,432,790 | $2.24 |

*The table is based on the population supplied, where separately reported; otherwise, on the total population by the census of 1900.

## INCREASING HEIGHT OF FLOODS IN THE LOWER MISSISSIPPI; THE PROBLEM AND ITS SOLUTION.*

By L. W. Brown, M. Am. Soc. C. E.†

### THE QUESTIONS TO BE CONSIDERED.

My acquaintance with the Mississippi River began in 1880. Twenty years ago the levees were of very small dimensions and very low in elevation as compared with those now existing. The important question is, what do these facts teach us and what conclusions are to be drawn? In my opinion, the facts as presented most conclusively demonstrate that to secure in the future the same protection against inundation as in the past and at the present time, there will be required a continual raising and enlarging of the levees, and the conclusions to be drawn are that in a very few decades (taking the past two decades as a criterion) the construction of levees to secure us properly against inundation will become a prodigious undertaking, both as an engineering feat and a revenue consumer. What will be the height of levees for proper future protection against the inundation of the Mississippi Delta, demands immediate attention and should be given the most careful thought and consideration.

What are the causes of the constant increase in elevation of floods in the lower Mississippi? Why do the maximum floods seldom, if ever, occur in yearly succession? Why should the maximum floods increase in elevation when a corresponding increase of discharge is not, by investigation, apparent? Why did the normal flood of 1898, discharging very considerably less volume than the great flood of 1851 or 1890, require greater flood elevation? The U. S. Government gaging of May 2, 1898, shows that the elevation of flood was 16.65 ft. on gage, and the discharge 1,084,000 cu. ft. per second, whereas on February 26, 1890, the flood elevation was 14.7 ft. on gage and the discharge 1,422,000 cu. ft. per second, which shows that the flood of 1890 discharged 338,000 cu. ft. per second, or 30% more water, and at an elevation of 0.95 ft. or 0.6% less than that of 1898. On March 17, 1851, the gaging as recorded shows a discharge of 1,153,000 cu. ft. per second with a flood elevation of 14.8 ft. on gage. When the causes are ascertained, what are the remedies to be applied or the methods to be adopted to maintain a comparatively uniform elevation of maximum floods?

### STATISTICS OF FLOOD LEVELS AND DISCHARGES.

Before attempting to lay before you an outline of my views of the cause producing the condition or the remedy to apply, I would refer to the following statistics and facts to amplify and form a basis for the conclusions and suggestions I may present.

All elevations used in this paper will refer to the Carrollton gage of the Mississippi River Commission, zero of which is 20.01 ft. above Cairo Datum, or 0.35 ft. below the mean ocean level; and all velocities and discharges referred to are those contained in the reports of the Mississippi River Commission. The distance from the Carrollton gage to mean ocean level in gulf is, for the calculation of slope, assumed at 120 miles.

I remember the newspaper reports of the flood of 1874, which flood overtopped the then existing levees, and later I became familiar with the effects of this great flood, which reached the then extraordinary maximum elevation

*Slightly condensed from a paper read before the Louisiana Engineering Society on March 11, 1901.

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of 15.7 ft. on gage, or 15.35 ft. above sea level, although the elevation of this flood was only 6 ft. higher than that of 1828, 46 years previous, and was not as high by 0.2 ft. as the flood of 1862, as recorded in the government records. The average slope of this flood of 1874 to sea level was 0.128 ft. per mile, or about 1 ft. in 8 miles. The records of velocity and discharge are not embraced in the government reports, but assuming the gagings of March 14, 1891, when elevation of flood was 15.6, as a comparative estimate of the velocity and discharge for flood of

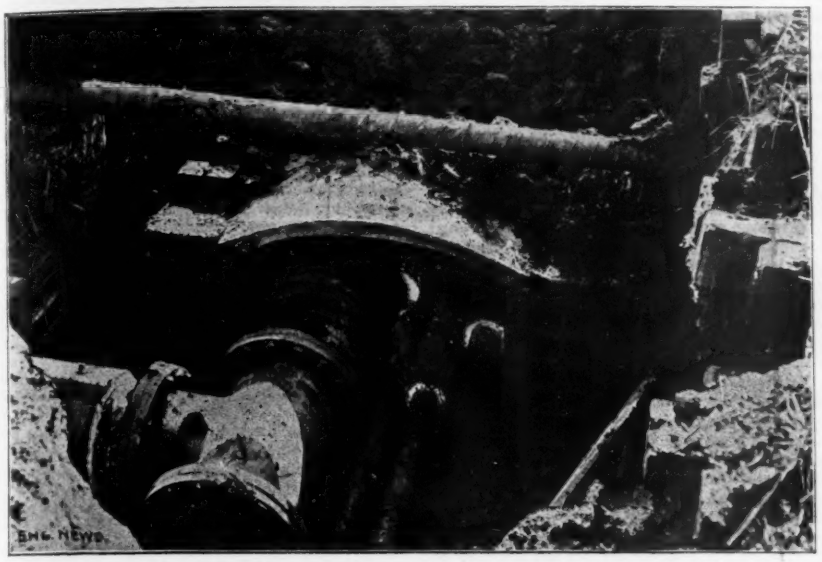



FIG. 2. COMPLETED SUBWAY, WITH PIPES IN POSITION.

1874, we have 6.95 ft. velocity and 1,202,000 cu. ft. discharge per second.

The flood elevation of 1874 was not surpassed until 1890, when it reached an elevation of 16.10 and in 1892 of 17.35, and 1893 of 17.45, and the greatest of all floods occurred in 1897, when the maximum elevation was 19.17 ft., or 3.47 ft. higher than the extraordinary flood of 1874, 23 years previous.

The elevation of flood of 1897 at Carrollton was 18.82 ft. above ocean level, and the average slope from Carrollton to ocean was 0.156 ft. per mile, or 1 ft. in 6.3 miles, or 22% greater than the slope of 1874, and while the government reports do not give the gaging as to velocity and discharge on the day when the greatest elevations were noted, viz., May 13, it gives for May 18 a velocity of 7.3 ft. and a discharge of 1,350,000 cu. ft. per second, gage reading 18.7 ft. and this gaging is the greatest, both as to velocity and discharge, of any shown in the reports, which further shows that while the difference in elevation of the flood of 1897 above the sea level was 22% more than that of 1874, 23 years previous, the discharge was only 12% greater.

The history of the great floods as recorded is given in Table I:

TABLE I.—Showing Dates and Proportions of the Great Floods of the Mississippi River.

| Dates. | Gage reading. | Height, ft. above sea level. | Slope per mile. | Velocity, ft. per sec. | Discharge, cu. ft. |
|---|---|---|---|---|---|
| 1828—April 1 | 15.2 | 14.85 | 0.123 | 5.90 | 1,099,000 |
| 1849—March 15 | 15.2 | 14.85 | 0.123 | 5.90 | 1,099,000 |
| 1851—March 27 | 15.4 | 15.05 | 0.125 | 5.99 | 1,118,000 |
| 1858—May 10 | 15.1 | .... | .... | .... | 1,168,000 |
| 1859—May 4 | 15.6 | 15.25 | 0.127 | 6.00 | 1,156,000 |
| 1862— | 15.9 | 15.55 | 0.130 | 6.68 | 1,243,000 |
| 1874—April 16 | 15.7 | 15.35 | 0.128 | 6.75 | 1,175,000 |
| 1890—March 13 | 16.1 | 15.75 | 0.131 | 6.90 | 1,292,000 |
| 1892—June 10 | 17.35 | 17.00 | 0.141 | 5.87 | 1,079,000 |
| 1893—June 22 | 17.45 | 17.10 | 0.142 | 5.82 | 1,113,000 |
| 1897—May 13 | 19.17 | 18.72 | 0.156 | 7.30 | 1,350,000 |
| 1898—April 25 | 15.90 | 15.55 | 0.130 | 5.73 | 1,024,000 |
| 1899—April 21 | 16.00 | 15.65 | 0.135 | 6.81 | 1,182,000 |

The velocity and discharge for years 1851, 1890, 1892, 1893 and 1897 are the results of gaging on these dates as contained in the reports of the Mississippi River Commission, but those for the other years are not given in the reports, and the velocity and discharge for these years are interpolated from the records of other years when gage readings or elevation of floods were the same, thus:

| The year. | Is from records of |
|---|---|
| 1828 | March 25, 1851 |
| 1849 | March 28, 1891 |
| 1859 | March 24, 1890 |
| 1862 | March 19, 1890 |
| 1874 | March 18, 1891 |
| 1898 | June 9, 1892 |
| 1899 | March 16, 1891 |

There is recorded no gaging since 1892 for flood elevation of 15.9 and 16 ft. for years 1898 and 1899, respectively, and the interpolations made are clearly on side of very greatest possible maximum velocity and discharge for these years. As it is most apparent, from the records, that the discharge for latter years is much less than in former years for same elevation of flood, as is shown by the records and gagings of the normal flood of 1898, when the elevations were from 15.50 to 15.65 ft., and the maximum discharge was from 1,049,000 to 1,087,000 cu. ft. as compared with that of all the great floods from 1828 to 1890, when the elevation ranged from 15.2 to 15.9 ft. and the discharge from 1,099,000 to 1,243,000 cu. ft. per second.

The records of the gaging on May 4, 1898, shows that with an elevation of 15.65 ft. the discharge was 1,049,000 cu. ft., with a velocity of 5.97 ft.; and it is perhaps safe to assume that the maximum volume of discharge of future great floods will approximte but not exceed 1,400,000 cu. ft. per second; hence the elevation of flood on May 4, 1898, to discharge a maximum flood of 1,400,000 cu. ft. at 6 ft. velocity, with cross section of 175,600 ft. at elevation of 15.65 ft. on gage, and assuming the width of the river between levees at 4,000 ft., would be 14.4 ft. higher, or 30.05 ft. on gage, and with increasing velocities would be as follows:

| | | | | | |
|---|---|---|---|---|---|
| Veloc. | 6.25—12.1 | ft. | higher, | or | 27.75 on gage. |
| " | 6.50— 9.9 | " | " | " | 25.56 " " |
| " | 6.75— 7.9 | " | " | " | 23.55 " " |
| " | 7.00— 6.1 | " | " | " | 21.75 " " |
| " | 7.25— 4.3 | " | " | " | 19.95 " " |
| " | 7.50— 3.1 | " | " | " | 18.75 " " |
| " | 8.00— 0.0 | " | " | " | 15.75 " " |

Hence to secure in 1898 an elevation of flood slope not exceeding 16 ft. on Carrollton gage, a velocity of 8 ft. per second would have been required to pass the maximum flood volume of 1,400,000 cu. ft., and with a velocity of 7.30 ft. per second, and a discharge of 1,350,000 cu. ft., as gaged on May 18, 1897, producing a flood elevation of 18.7, the maximum flood elevation of 1898, to pass this volume at this velocity would have been only 2.3 ft. higher, or 17.95 on gage, or .75 ft. lower, which clearly demonstrates that the floods with maximum elevations, even with equal volume of discharge, cannot occur in succession, for the reason that the avenues for passage of water are scoured out by the first flood and the conditions to retard the passage cannot be formed in the interval of time between two flood periods. The velocities shown above, and which exist in the lower Mississippi, are very heavy; even the lowest is not consistent with any reasonable security of bed or banks, as is shown by the following experiments of Bazalgette, in which he found the velocity required to move materials as follows:

| | Ft. per sec. | | Ft. per sec. |
|---|---|---|---|
| Fine clay | 0.25 | Fine gravel | 1.00 |
| Sand | 0.50 | Pebbles | 2.00 |
| Coarse sand | 0.66 | Stones, egg size | 3.00 |

And the observation of eminent hydraulicians as referred to by Ganguillet & Kutter give mean velocities required to abrade river beds and banks as follows:

| | Ft. per sec. | | Ft. per sec. |
|---|---|---|---|
| River mud | 0.33 | Common river sand | 0.92 |
| Sand, size of aniseseed | 0.46 | Angular flint stones, egg size | 4.23 |
| Clay and loam | 0.66 | Soft slate | 6.45 |
| Sand, size of peas | 0.79 | Stratified rock | 7.86 |
| Coarse gravel and small cobble stones | 3.93 | Hard rock | 13.12 |

From which it is not surprising that with a current having a velocity of from 5 to 7.30 ft. per second the alluvial banks of the Mississippi River are abraded.

## RATE OF INCREASE OF FUTURE MAXIMUM FLOOD ELEVATIONS.

The facts as presented above make prominent the further very pertinent question, what will be the rate of increase of future maximum flood elevations? Referring to the above list of great floods, we find that from 1828 to 1874, a period of 46 years, the increase was only .5 ft., or at a rate of .011 ft. per year, or 1 ft. in 90 years, while the flood of 1897 was 3.47 ft. higher than the flood of 1874, or a rise of 3.47 ft. in 23 years, or at a rate of .15 ft. per year, or 1 ft. in 6½ years. It will be noted, further, that in 1890 the elevation of maximum flood was 16.1, or 0.4 ft. higher than that of 1874, or 0.4 ft. increase in 16 years, or at a rate of .025 ft. per year or 1 ft. in 40 years, while the flood of 1890 was 3.07 ft. below that of 1897, or an increase of maximum flood elevation of 3.07 ft. in seven years, or at a rate of 0.44 ft. per year, or 1 ft. in about 2½ years. It is also interesting and instructive to note that the maximum elevation of floods since 1897, while they have been considered as normal, were all considerably higher than those of the great flood periods prior to 1890.

A careful consideration of the facts above presented, showing the increase of elevation of maximum floods, would determine as conservative a rate of increase in future of 1 ft. in five years, and it is to be feared and may be expected, that this increase will be exceeded. Hence, unless means are adopted to thwart the gradual increase of maximum elevation of floods, the levees in 1950 will be 10 ft. higher than at present, under which condition the whole delta will be confiscated for levee protection and commerce on the lower Mississippi will be rendered wholly impracticable.

Mr. Chas. Ellet, who represented the United States government in connection with river investigation in the year 1851, was sufficiently bold to assert that to sustain a flood of the intensity of that of 1851, the levees must be made 2 ft. higher than they then existed, from Red River to New Orleans—for which assertion he was, in 1861, severely criticised by the United States government's representatives in charge of river matters. As a matter of fact, the floods of 1851 were no doubt as intense as those of 1897,

FIG. 3. STEEL-CONCRETE ROOF SEGMENTS FOR PIPE SUBWAY.

and while the maximum discharged at Carrollton, as gaged, was 1,186,000 cu. ft. per second, and that of 1897, 1,350,000 cu. ft. per second, the volume passing from the river into the sea between the Red River and New Orleans was equal to or greater than the difference between the measured discharge, and the prophecy of Mr. Ellet has been more than realized, as, in lieu of 2 ft., levees to properly protect the alluvial lands are now fully 5 ft. higher than they were in 1851.

The estimate made by the government engineers in 1861 for the proper and absolute protection of the alluvial lands

along the Mississippi River, from Cairo to the Gulf, in addition to the value of levees then existing, was $17,000,000, and the value of then existing levees was placed at $9,000,000, making the total value of the ultimate and complete levee system $26,000. There have been expended since 1861 up to the present time, and the levees are yet incomplete, upwards of $50,000,000, and, to protect properly the alluvial lands against inundation in the future, as far as 1950, the levee system alone, if built at once of proper proportions, will cost upwards of $100,000,000, but a very much greater amount will be expended by reason of the work of raising and enlarging the levees, which will necessarily be required to be done gradually, and oftentimes as an emergency, and at no time will the alluvial lands be absolutely free from the danger of inundation, unless the increase of flood elevation is restrained.

The facts above presented, and the conclusions to be drawn, are most thoroughly convincing that the elevation of the surface of normal and extraordinary floods in the lower Mississippi are increasing, which conclusion presents, in contemplation, most undesirable future conditions and invites our most serious attention.

## FAILURE OF "ALL-LEVEE" SOLUTION.

The methods adopted in the treatment of rivers in Europe, traversing alluvial territory, such as the Rhine, Vistula, Danube and others, cannot be adopted, as these methods have utterly failed in restraining an increase of the elevation of their floods; and, again, these rivers are very small in comparison to the Mississippi, and such measures as would increase, almost imperceptibly, the elevation of floods in these small rivers would make the increase in the Mississippi River most apparent.

When the "all-levee system" was inaugurated and urged between the years 1860 and 1880, no marked increase in the elevation of floods was apparent—in fact, the records show an increase of only 0.9 ft. from 1828 to 1890, a period of 62 years, while from 1890 to 1897 the records show an increase of 3.07 in seven years, and the engineering profession, more particularly the government engineers, in recommending the "all-levee system" did not take into consideration the consequent and serious effect of increasing the elevation of floods.

Were the Mississippi River not leveed in, it would, when rising above its normal bank, overflow and deposit its sediment on the adjacent banks and the surrounding country, and as it gradually elevated its banks and the surrounding country, and gradually withheld the water from overflowing, it would scour a channel of the desired width and depth to convey the volume to the sea-level at such velocity as the bed would allow, and the elevation of the flood height would be a purely natural one, coinciding with the distance and volume, and the elevation would gradually increase as the river extended into the Gulf, which, under present conditions, is less than 200 ft. per year, and in 1,000 years would be about 40 miles, or sufficient to raise the flood elevation at Carrollton about 1 ft., and, according to government statistics, it would take something like 720 years to raise the 29,000 square miles of alluvial territory 1 ft.; so that if the Mississippi River were left alone the time would be very remote when the elevation of floods would increase 3.47 ft., as has taken place in 23 years, or between 1874 and 1897.

One of the main causes of the increase of flood elevations is due to the construction of the levees on lines not calculated to maintain a constant cross section in river, or especially of that portion of volume which flows above the natural bank, and affords an opportunity for the volume to lose its velocity at points where levees are placed comparatively far apart, and thus requires an artificial head to cause the volume to resume its flow through a more confined portion of the river. This elevation of the volume in the wide portions further reduces the slope and velocity of the river above, and hence affects the whole river and interferes with any uniform velocity. Further, the low velocity thus produced at points is sufficient to form deposits and decrease cross section, which, in turn, causes further elevation of flood surface, and produces at other points such intense velocity as to abrade the bed and banks, and oftentimes materially increases the length of main channel. This is also true of other points where the river itself and levees are wide, as compared with other points, where the river and levees are narrow, producing relatively low and relatively high velocities, rendering impossible any uniform velocity. Again, there are places where the river is entirely too narrow to pass properly the floods, and some of these narrow points are highly improved as at New Orleans.

Another cause for the increase of elevation of floods, and fluctuations in elevations for equal volume of discharge is due to the changing of the bed of the river and to the moving back of levees around bends, thus materially increasing the distance to ocean level. This reduces the slope and the average velocity.

Another cause may be assigned to the accretions which form on the bottom and sides of the channel on the apex side of bends, without a corresponding amount of abraison on the concave side, during seasons of normal floods. This condition may increase for a year or two, when a flood with a very high elevation ensues, which is produced not so much by a greater volume as by the choked cross section of river channel.

The combination of all these causes produce a constant stop and start, retardation and acceleration of velocity, causing excessive accretions at one point and excessive abrasion at another, cutting out a channel through a choked cross section at one place and depositing it in a cross section of superabundant area at another place, until it in time becomes choked, and thus the elevation of the floods is constantly varying and steadily increasing, due to the increase of resistance for channel to clear itself of deposits. The yearly extension of the river into the Gulf, as affecting the slope, is insignificant and requires no consideration as affecting the elevation of floods, excepting for periods of time marked by centuries.

That the elevation of great floods is increased by reason of greater volume cannot be conclusively determined in the affirmative. Were the elevation of normal floods not increasing in practically the same ratio as the elevation of the great floods, more consideration could be given to the great increase in the volume of one great flood over that of another.

The careful consideration of the records of great floods for the past 70 years would clearly indicate that the volume is not increasing, and there is every reason why the maximum volume should not increase with the settling up and improvement of the country over that of the great floods which occurred when the whole country tributary to the Mississippi was wholly unimproved. The opening up and improving of the country has very largely increased the percolation and retention of water on the lands, and the installation of industrial enterprises retains large quantities which formerly were precipitated to the Mississippi immediately the warm season opened, and, with further development of the country, this volume, which will be retained and allowed to run off gradually, will greatly decrease the maximum volume of future floods, and even with the worst combinations and most undesirable conditions as to the breaking up of seasons of cold weather, the maximum volume of future floods should not exceed the maximum volume of the great floods of the past. It is, however, possible, and even probable, that very great future advantage will be secured to the lower Mississippi by the construction of further works having for their object the further retention of water for irrigation, or other purposes of the territory tributary to the Mississippi, and thus entail a double benefit.

## PROPOSED SOLUTION OF THE PROBLEM.

The suggestions as to the methods to adopt to secure the very lowest possible permanent maximum flood elevation for the lower Mississippi (18 ft. or less at Carrollton) are replete with material for discussion and consideration.

PRELIMINARY STUDIES.—The first steps towards securing satisfactory results would be to provide a firm base or foundation for such conclusions as may be reached by the inauguration of measures to secure full and complete data and information of all the conditions now existing which have a bearing on the subject, and to this end it would be necessary to correlate and place in such shape as can be utilized all the data secured by the United States government and Mississippi River Commission, and all the reliable data which can be furnished by levee boards, levee engineers or other parties, and fill in with the best possible judgment by interpolation or otherwise, the data covering past conditions which are not attainable, and then proceed to arrange for the securing of accurate data of all the conditions, as to cross section of channel throughout the whole length of the lower Mississippi; make complete investigation as to direction and intensity of currents, and of all abrading and accretioning banks; secure all data necessary to determine positively the cause for any and all of the varied actions of the river, such as accelerated and retarded velocities, shoaling and scouring of bed, accretioning and abrasion of banks; also note all the conditions necessary to determine the practicability of the adoption of such remedy as may be determined upon; make full investigation and survey of all low alluvial lands and note all the conditions necessary to determine as to the practicability of their utilization as relief avenues for the floods, and at the same time assist in making these low lands suitable for future agricultural enterprises—in fact, to make the whole investigation as thoroughly complete as possible, and thus enable the whole subject to be studied and considered in all its phases, which might perhaps result in the adoption of methods quite inexpensive and most efficient, not thought of now, for the securing of the object sought to be obtained, and at the same time provide very great advantages to industrial and commercial enterprises.

REGULATION OF CROSS SECTION.—In absence of full and complete data and information on all points bearing on the subject, or rather in the light of such information as is now before us, it would appear that to provide proper protection of the Mississippi Delta against inundation there must be provided, in addition to levee building, a reasonably uniform cross section of river, especially for the volume flowing above top of natural ground, and the levee should be located to provide this requisite, and future location of levees should be determined by the calculation for volume and velocity of river at any point for the purpose of providing proper cross section, rather than by such physical conditions as may exist, as is the present practice.

Measures must also be adopted by which the extensive caving by reason of constant and heavy abrasion of banks in bends will be measurably retarded; and to accomplish this end, the heretofore condemned suggestion of removing accretioning bends or points, can no doubt be practiced with great benefit. The desired requisite to be secured, to maintain a low and uniform elevation of floods, is a channel which is of proper cross section to carry, with a reasonable velocity, the volumes received; and a careful investigation of the channel after each high water will give the data necessary to determine by calculation what work will be required to be done in removing accretioning banks, bars, or other obstructions to secure the proper channel for the ensuing season.

Should the investigation disclose the fact, which in all probability it will, that at places the river is too narrow and the levees too close, the latter must be removed and conditions provided by which the river will cut a channel of the requisite cross section; where choked cross sections exist at points where valuable improvements are located, on the adjacent banks, as at New Orleans, the additional channel area which is required may be secured by a spillway extending from a point just above the city and connecting the river at the English Turn; the ends of this spillway to be located at an elevation of say 13 ft. Carrollton gage, or such elevation as may be determined as coincident with the volume, section and velocity safe to pass New Orleans.

This spillway will assist in maintaining a velocity in the main channel past New Orleans such as will not cause the heavy abrasion now sustained by reason of the high velocity required to pass flood volumes.

RESERVOIR SYSTEM.—I am of the opinion that the suggestion made by Brigadier-General B. S. Roberts, U. S. A., to reclaim waste swamps along the lower Mississippi by utilizing the delta making material of the surplus water of the river, will, with some modification, prove most beneficial to all interests. I am convinced that such measures will also form a most important factor in maintaining a correspondingly low and permanent elevation of floods, and render unnecessary the large future expenditure for levee construction, as also provide the greatest possible security against inundation, notwithstanding the fact that the suggestion of General Roberts was condemned and criticized as a project having no merit, by the government engineers in charge of the Mississippi River improvements.

The measures I would suggest, as modifications of the plan presented by General Roberts, would be such as not only affect flood slope of river and vastly improve the low lands, both from a financial and sanitary point of view, but would further provide an invaluable supply of water for irrigating the land during the low-water season, which is not infrequently accompanied by a long season of drouth. To this end, there should be located at such points as the survey and investigation would best determine, a spillway of such construction as to be positively free from danger of washing out. This spillway should be connected by levees, across the high ground adjacent to the river, with a large reservoir or basin constructed directly in the low ground or swamps. The size of this basin should be such as conditions may determine—for illustration, say 10 miles long and 5 miles wide, embracing an area of 50 square miles. This reservoir could be constructed by dredges from the inside and forming the proper levee around same to such height as may be determined—say of sufficient height to maintain the surface of water at an elevation of 5 ft. above the high land adjacent to river when the spillway has ceased to run.

At any desired point in the levee, forming the reservoir, a spillway would be constructed to allow the water from the river to pass directly to swamps after filling the reservoir. The surface of the swamps will thus be gradually raised by the deposits from the river water, and any territory desired can be elevated by construction of small levees to direct the flow after the water leaves the reservoir. Thus, at small expense, the whole territory adjacent to the reservoir will be elevated in a few years. In the course of time, say 25 or 30 years, or when sufficient filling has taken place, the spillway and reservoir could be abandoned and new ones constructed at other points, and thus the alluvial territory along the river would be constanly elevated, co-extensive with, and perhaps at a greater rate, than will the elevation of floods increase from natural causes. The reservoir of the dimensions above referred to, holding 5 ft. of water, would contain 6,969,600,000 cu. ft. of water when flood in the river recedes below elevation of sill of spillway; and this volume of water could by gravity be used to irrigate the adjacent lands during a dry season. On the assumption of there being required for proper irrigation an acre foot or a depth of 12 ins. of water over the whole territory to be irrigated, the volume would irrigate 160,000 acres of land, and a low estimate of the value of such irrigation would be $5 per acre, which would aggregate an advantage amounting to $800,000 per annum, or 10% on a capitalization of $8,000,000, not including the advantages accruing from the elevation of these lands, making them productive, and at the same time removing extensive malaria breeding areas and improving the sanitary condition of the territory.

The dimensions of the spillways and reservoirs would be such as would be determined by the survey and full consideration of the location selected; approximately, the spillway would be 5,000 ft. long and have a maximum ca-

pacity to deliver 60,000 cu. ft. per second—and it would be judicious that a sufficient number be constructed to have an aggregate maximum discharge of 400,000 cu. ft. per second, or say eight in number, located at such points as to cover the low ground to best advantage and make connecting levees as short as possible. In the main, these large spillways and reservoirs should be located on the right bank, as larger areas of low land lie on this side of the river and the connection with the sea is more direct; although several small spillways and large reservoirs could be located to great advantage on the left bank.

Closer investigation and experience will determine the volume which can be, with best advantage, passed from the river to spillway, but for economic interest, the volume allowed to flow over the low lands, as proposed, should be as large as possible, and perhaps it may be wise to exceed the volume of 400,000 cu. ft. per second above referred to. This may be done without decreasing the velocity in the river sufficient to cause deposits. The volume in the river when it recedes to the sill of the spillway may be most advantageously fixed at such volume as will produce a velocity not exceeding 5 ft. per second, or a maximum discharge of about 800,000 cu. ft. per second.

As above represented, the annual value of spillway and reservoir for irrigation would approximate $800,000 for each spillway having capacity to discharge 60,000 cu. ft. per second and reservoir embracing 50 sq. miles, which for eight, or sufficient to discharge 400,000 cu. ft. per second, with corresponding reservoir capacity, would amount to $6,400,000 per annum, or 10% on a capitalization of $64,000,000. The cost of the spillways and reservoirs would depend on location, but approximately the cost of each would not exceed $600,000, not including value of land occupied.

The above, however, does not reperesent all of the direct advantages which would be secured. The elevating and reclaiming of the low land will, in time, produce an advantage of enormous value, and land now worth $1.25 per acre will become the most fertile and productive in the Union, and the crops grown will yield a revenue equal to 10% on a capitalization of from $50 to $1.50 per acre.

The suggestion, as will be observed, contemplates the delivery of water on to the low lands at such velocity and in such manner as will admit of deposits forming adjacent to reservoir, or at any point desired, by the construction of small supplemental levee, and obviate entirely the high velocities and heavy abrasion of land, and uncontrollable points of deposit which are secured by a sill and side levee to the low land, which is practically a leveed crevasse; and further secure the irrigating reservoir. It would be pertinent to remark that the irrigation of our lands is a progression which in the very near future will be most fully appreciated, and will be adopted wherever an opportunity offers. For the purpose of irrigation, large reservoirs with small spillways could be placed along the upper Mississippi.

Allowing that 400,000 cu. ft. per second is passed by eight spillways and allowed to deposit on low ground for an average period of 120 days each year, and that the water contains of solids, 1 part in 1,500 parts, the deposit per year would be 5 ins. deep over an area of 250,000 acres, or 5 ft. deep in 12 years, or on an average it would fill 63,470 acres 1 ft. deep each year, and in 100 years it would fill 6,347,000 acres 1 ft. deep.

This illustrates the enormous amount of earth carried by the Mississippi each year and deposited in the Gulf of Mexico.

## TWO GOVERNMENT DOCUMENTS ON THE PREVENTION OF HAILSTORMS BY CANNON.

In our issue of Sept. 6, 1900, we commented upon a consular report describing recent French experiments in warding off hailstorms by cannon discharges. Since that time two interesting documents relating to these experiments have come to us, one of them a further report by the U. S. Consul at Lyons, the other an editorial comment upon these experiments in the "Monthly Weather Review," the official publication of the U. S. Weather Bureau. We reprint each of them, somewhat condensed, below:

### REPORT OF JOHN C. COVERT, U. S. CONSUL, LYONS, FRANCE.

Since I sent the Department a report on the firing of cannon at clouds to prevent the destruction of grapes by hailstorms, several newspapers and a number of individuals have requested that "the consul at Lyons make a supplementary report on this subject." With this object in view, I accompanied Mr. Jean Raulin, a professor of agriculture and an official of the Farmers' Alliance (Syndicat Agricole), of the southeast of France, in a visit to the towns of Bois-d'Oinget and Denice.

In the first place, all the grape growers of the neighborhood had been invited to witness the trial of two guns, especially constructed as hail destroyers. In the second place, Denice, a general jollification was organized to give vent to the joy of the grape growers over their success in vanquishing their most dreaded enemy—the hail. Two long cannons were displayed in each place, almost identical in shape, but differing in the manner of firing. The accompanying cut represents both.

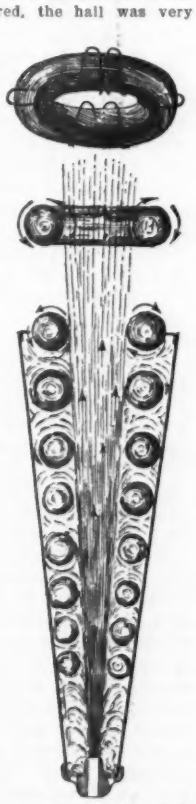
Each gun is of the shape of an inverted cone, the opening at the mouth being 28½ ins. wide. It is planted upon a tripod 3 ft. high. The gun itself is 6 ft. 6 ins. high above the tripod. It is made of thin boiler iron. At its base is a forged breech, which holds a forged iron block. In the center of this block is an aperture 6 ins. long, about the size of a large dynamite cartridge, in which is placed a metallic cartridge containing 80 grams of blasting powder, wadded with a cork and tamped like an ordinary miner's blast. It is discharged by a needle on a lever attached to the base of the forged iron holder.

As many as 50 shots were fired in my presence in order that I and Vice-Consul Browne might inspect the working of the guns. The detonation is very loud. As soon as the lanyard is pulled, flame is visible at the mouth of the gun, followed immediately by a wreath of smoke. The action of the powder on the air is represented in the accompanying cut.

A shrill whistling sound immediately follows the firing of the cannon and is heard for 14 seconds. At a distance, this whistling is much louder than near the gun. I am told that it travels at a speed of 330 meters per second—4,620 meters in 14 seconds, which is nearly 2½ miles. During the firing a few drops of rain fell.

I interviewed from 20 to 30 large wine growers who used the cannon last summer. They were all emphatic in their belief in the efficacy of fighting hail with gunpowder. They said that if the weather were hot and they saw the clouds forming, they prepared for a charge. If the clouds were moving rapidly, their direction was changed or the movement was stopped by the firing. They were torn asunder and broken into shreds, and a copious fall of rain soon followed. In localities where great losses from hail have been incurred every summer, the cannons were used last summer and no hail fell. Two or three miles distant, where no cannons were fired, the hail was very destructive. At Denice the grape growers have suffered from hail seven years out of the last decade. They think all the conditions favored hail last summer and that they were protected from its destructive ravages by their cannon. One cannon protects nearly 75 acres of land.

Cannon Used to Ward Off Hail Storms.



Supposed Action of Explosive Upon the Air.

Dr. Paul Cazeneuve, one of the most distinguished scientists of France, says the question is still in the domain of experiment and that nothing is proven; "that the commune of Denice was not this year on the line of the hailstorm and was only spattered by the heavy surrounding storms." He adds that "if a number of communes where cannon were fired were on the line of the hailstorm and were protected and the others were subjected to great losses from hail, that would prove the efficacy of the cannon." The wine growers say this is just what happened. Dr. Cazeneuve thinks that no amount of cannon firing would influence great storms, and asks what these cannons would have done against the terrible cyclone at Galveston. But he thinks the experiments should be continued "systematically and scientifically" and that "when it shall have been demonstrated that moderate hailstorms can be conjured, then it will be time enough to take measures against hurricanes."

In 1899, 2,000 cannon were engaged in cloud shooting in Italy. Last year the number had swelled to 15,000. The Italian government goes so far in recognizing the efficacy of the cannon as to furnish powder to grape growers at 3 cts. per lb.

Before the present improved cloud destroyers were in use, vine growers shot powder from a sheet-iron case fixed in a strong box on the trunk of a tree. In some parts of France they rang and still ring church bells, believing that the vibrations in the atmosphere affected the elements. If the hail continued to fall in spite of the ringing, they averred that it would have been worse but for the clangor of the bells.

### EDITORIAL IN THE "MONTHLY WEATHER REVIEW."

In answer to numerous inquiries about shooting at hail clouds for the purpose of dispersing them, the editor would state that although statistics show that during the past year 15,000 shooting stations were established in Italy and a very large number in Southern France and Austria, yet there is no evidence whatever that the shooting done by these stations has had any effect whatever upon the hailstorms or the hail. Generally the quantity of powder used is so small that the vortex rings are not able to ascend farther upward than 1,000 ft. They do not, therefore, reach the clouds; and if any effect could be produced upon the hail, it could only be by virtue of the noise or the dust, and these are far less than those made by Dyrenforth in his experiments with dynamite in 1892. The very sensible report of the director of the agricultural societies of the southeast of France says:

We cannot conclude that the use of cannon will always afford complete protection, but it is undeniable that the results obtained are very interesting.

The recent congress of hail-shooters at Padua (Nov. 25-29, 1900) could only conclude that we are in the midst of an extensive experiment, and that several years' work will be required in order to ascertain the true effect of the cannonading.

In some parts of France for several centuries it has been the custom to ring the church bells when a hailstorm is approaching. The modern newspaper writer guesses that the people do this by reason of their belief in the efficacy of the sound of the bell, but the historical fact is that this was originally simply an invitation to all good churchmen to unite in prayer for deliverance.

There is no doubt that the cannonading is believed to be effectual by the farmers who do the work, otherwise they would hardly continue the labor and expense, and yet we must remember that waves of irrational enthusiasm sometimes sweep over a community only to be regretted in subsequent years, when a calmer judgment has come to prevail. The fact that 10,000 or 20,000 shooting stations have been established is of itself no argument as to the efficacy of the process. One might as well argue that the moon really affects the weather because a million people believe it, and can prove it—to their own satisfaction. A knowledge of the exact truth on any question of natural science is not easily attained, else the world would long since have progressed far beyond its present status in knowledge and civilization. The most common errors among mankind are those that are based upon fallacies in reasoning rather than errors in observation. Thus, in the present case, we have innumerable reports to the effect that "a black cloud was seen approaching, cannon were fired, and the cloud passed over without hail," or "it passed to one side and the hail did not fall on the protected vineyard," or "it advanced to the edge of the vineyard and there the hail ceased," or "the cloud broke in two, passing to the right and the left, leaving the sky cloudless over the cannon." Now all these are quite common cloud and storm phenomena; they will happen oftentimes without any cannonading. The best friends of the Stiger or Italian method of annihilating hailstorms have recently confessed that the method is still in its infancy or experimental stage and that it is still necessary to investigate and demonstrate its value.

CONCRETE LAID IN FREEZING WEATHER was tested recently in the new Inter-Ocean Building, now in course of erection in Chicago. The concrete was not made with stone, however, but was a cinder concrete used for the floor arches. It was composed of 1 part Alpha cement, 2½ parts torpedo sand and 6 parts cinders. The arch tested had a span of 5 ft. 7 ins. c. to c. of the 15-in. 60-lb. I-beams of the floor framing, and was 2¾ ins. thick at the crown. The system of construction is that patented by the Roebling Construction Co., of New York and Chicago, the arch having a permanent centering of wire netting reinforced by iron rods, this centering resting upon the lower flanges of the I-beams. The concrete was put in place during the last week in January, when the building was not enclosed, the concrete being exposed to the weather, while the temperature was a few degrees above zero. The test to determine the strength of the concrete was made on March 29 and 30, the arch being then two months old. Two slots were cut through the floor, forming an isolated length of 3 ft., upon which was laid a bed of sand 3×5 ft., 2 ins. thick. Three courses of brick were laid upon the sand and a platform 3×8 ft. was placed on the brick to carry the loading, which consisted of bags of cement. The total load applied was 24,000 lbs. on an area of 15 sq. ft., or 1,000 lbs. per sq. ft., under which load the total net deflection at the center of the arch was 5/8-in. The test was made under the direction of Mr. W. Carboys Zimmerman, architect of the building, and the result is considered as a proof that this system of cinder concrete construction can be built during any kind of weather and at any temperature.

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*ADVERTISING RATES:* 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*


A new project for an electric railway to operate at very high speed is reported from Germany by the U. S. consul at Frankfort. According to this report, the line is run from Berlin to Hamburg, 156 miles, and trains are to be run at 125 miles per hour, at intervals of six minutes.

For more than a dozen years, schemes for high-speed electric railways have been brought forward; but they have one and all vanished into nothingness. The fact is that nobody has yet operated an electric train at speeds as high as have been reached by trains hauled by steam locomotives. It is yet to be proved that if it is desired to attain regular speeds higher than those now common in ordinary railway service, electricity is in any way better or more economical than steam. The idea has been frequently put forward that because the steam locomotive has a reciprocating motion and the electric motor a rotary motion, the former cannot be used for such high-speed service as the latter. This, however, is so far a purely theoretical assumption, unsupported by any actual facts. In our opinion, locomotive designers are quite as well able to build machines to run at 125 miles an hour as are the designers of electric motor cars. The locomotive men will have no more trouble in taking care of the reciprocating motion matter than the electric designers will in collecting current at such speeds, or in so mounting their motors as to avoid that punishment of the track, which is so conspicuous a feature of electric railway operation, even at the moderate speeds of street cars.

In our issue of Oct. 1, 1896, we gave an account of the Goodyear experiments in dredging with dynamite on the outer bar at Brunswick, Ga. We then remarked that from all the information at hand, if the amount which had been expended on the dynamite explosions had been used in dredging, a good deal more would have been accomplished.

Recently a report on the Brunswick dynamite work has been made by Capt. C. E. Gillette, Corps of Engineers, U. S. A., and an abstract of this report is presented in another column. The conclusions reached by Capt. Gillette are summarized as follows:

1. Dynamite does not have any useful effect in bar deepening, except in loosening tough materials in the immediate vicinity of explosions. Such materials are very rare on bars along sandy coasts.

2. The channel now existing at Brunswick Bar has been produced by nature, aided very materially by ordinary dredging. The useful effect of dynamite has been very small, except, possibly, to loosen materials in some places as an aid to the dredge.

3. The cost to the government of all material removed, whether usefully removed or otherwise, has been $1.13 a yard, more than seven times the cost of ordinary dredging. The cost to the contractor is stated to have been even more than this.

4. The channel produced has no advantage of permanence over a dredged channel of similar size and location, which could be produced for about one-twelfth of the cost of the present channel.

The United States has paid to Mr. Goodyear $220,000 for his work, and has expended about $27,000 more in surveys to determine what improvement has been made on the bar. In all, therefore, about a quarter million dollars of public funds have been spent in a Quixotic experiment, doing work that an ordinary dredge would have done for less than $20,000.

We commend these facts to the careful consideration of those who are trying to lay the blame for the waste of public money in River and Harbor works upon the members of the Corps of Engineers. The fact is, as every intelligent engineer or contractor knows, that to explode dynamite on an ocean bar in the hope of creating a channel was about as likely to accomplish valuable results as General Dyrenforth's bombardment of the Texas skies to make rain fall. The Government engineers from the beginning advised Congress against expending money upon the Goodyear experiments; but Congress in its wisdom (?) thought it a good scheme to let Goodyear try, as they let Dyrenforth try, and the final result is a waste of public funds.

Since the defeat of the River and Harbor bill, various attempts have been made to lay the blame for unworthy appropriations for River and Harbor work upon the officers of the Corps of Engineers. The Washington correspondent of the New York "Tribune," for example, has suggested that the control of River and Harbor work is likely to be transferred to civilian engineers. We attach no importance to any such prediction; but it is only fair to point out that the attempt to lay the blame for River and Harbor bill absurdities upon the Corps of Engineers is a gross injustice. It must be stated, as a matter of fairness, that while the Goodyear dynamite work was universally condemned from the outset by the army engineers, several civilian engineers were found to defend it. The evils of present methods of conducting River and Harbor works are many; but a mere transfer of control of the work to civilian engineers would effect nothing to remedy them. Rather, if we may judge from such fiascos as that at the Brunswick bar, it might open a wider door to corruption and extravagance.

A friendly criticism of the Master Car Builders' Association (and incidentally of other associations in which car builders are interested) was made by one of the most active members and officers of that Association at the March meeting of the Western Railway Club. In opening the discussion of the paper presented at that meeting, Mr. S. P. Bush, Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul Ry., made the remarks in question, which we reprint below:

I am beginning to feel that the various organizations of the country in which car builders are interested, particularly the Master Car Builders' Association and the railway clubs, ought to be more interested than they are in taking some definite position with reference to car construction. The Master Car Builders' Association has had its life in the making and adoption of rules for the interchange of cars, but for the last two or three years we have attended the conventions, and hurried through with the rules just as fast as possible so as to prevent making any changes, and no doubt this has been wise. But aside from this, the Association has done little else, and it begins to look as if it did not have very much to do except to appoint a committee for this and a committee for that and to adopt something as a "recommended practice."

Now, I am one of those who believe that if the Master Car Builders' Association and the railway clubs of the country are going to exist for any good purpose, they ought to be willing occasionally to take some positive position on something. I think that the Master Car Builders' Association ought to have a large influence and to be a great factor in molding opinion in the matter of car construction. I think it could do it by adopting certain fundamental principles. The railway clubs afford a splendid opportunity to discuss these subjects, that the Master Car Builders' Association and Master Mechanics' Association may act upon them in some positive manner. One of the things that the Master Car Builders' Association could with perfect propriety take some action on would be the adoption of certain principles in car construction and it would be an excellent time to take that position, as we are just beginning to go into steel-car construction.

It is not necessary to discriminate against this special construction or that special construction; but if we are going to interchange cars, one railway with another, as generally as we do to-day, it would be perfectly proper to adopt certain principles with a view of obtaining construction that will be serviceable, economical to maintain, and which will make the operation of interchange and repairs for each other a simpler matter than it is to-day.

This is not an isolated criticism of the Master Car Builders' Association. Similar remarks have been made (though usually in private) by other railway officers and members of the Association, the trend of the criticism being that the M. C. B. Association is giving too much attention to minor details of construction and to the problems of interchange, and too little attention to important matters concerning the general principles of design and construction of cars for modern conditions of operation.

Although the steel car has ceased to be an experiment, and is now in very extensive and increasing use, it has been given little official attention by the Association, and it would certainly seem to be desirable that it should be made the subject of some general investigation. With many designs of steel car construction now in use, and others in process of development, we think the members of the M. C. B. Association (and railway officers generally) would welcome the appointment of a strong committee at the next convention to consider the steel car question and eventually, perhaps, to report upon standards to be observed in the design and construction of such cars.

The questions concerning the control of floods in the Lower Mississippi are again brought forward in a paper by Mr. L. W. Brown, M. Am. Soc. C. E., recently read before the Louisiana Engineering Society and reprinted on another page of this issue. Briefly summed up, Mr. Brown's argument is that the flood heights in the Lower Mississippi River are steadily increasing and making necessary continual increases in the height of the levees. Evidently, if this increase is to continue, a point will soon be reached where levee construction will be a financial impossibility. Every engineer will understand how largely the cost of levees increases with every increase in their height, and also how greatly every such increase in height magnifies the danger of crevasses and the destruction wrought when they occur.

From this basis Mr. Brown argues that a reservoir system, in some form or other, ought to be combined with the levee system; and he outlines a plan whereby a reservoir system in the delta might be made available not only for flood control, but for irrigation.

In enumerating the causes for the increase in flood heights, Mr. Brown does not mention what has heretofore been considered the most important, viz., the construction of levees. As the late Major Wm. Starling clearly explained in his valuable papers, published in this journal in 1897, the protection of each additional river basin by the Mississippi levees has been followed by increased flood heights. Nothing else could be expected. When a swollen river is confined to its main channel a mile or so in width, instead of being allowed to spread its waters over the whole bottom land for a breadth of 30 miles or more, an increased flood height is certain. What this flood height is likely to be is, as Mr. Brown well says, the most important problem that can engage the attention of the engineers who are working on the problem of Mississippi River control.

It is encouraging to remember, however, that

while flood heights have been considerably raised in the Mississippi by the cause named during the past twenty years, we need expect no similar rate of increase in the future. The entire Lower Mississippi from Cairo to the Gulf is now held in by levees with the exception of the St. Francis basin. When that is enclosed, no further increase in flood heights from this cause need be feared.

## METERS AND WATER CONSUMPTION IN THE LARGER CITIES OF THE UNITED STATES.

Selling water by guess has now few advocates among water-works engineers and superintendents. In fact, nearly all men held directly responsible for ample and pure municipal water supplies have had the necessity of using meters forced home in such a variety of ways that they now believe in as rapid an extension of the meter system as popular feeling, or prejudice, will permit. The extent to which these convictions, on the one hand, and prejudices, on the other, prevail in the larger cities of the United States is indicated by some figures on water consumption and the use of meters during the year 1900, presented elsewhere in this issue. The information was collected and tabulated by Mr. Geo. I. Bailey, M. Am. Soc. C. E., Superintendent of the Bureau of Water at Albany, N. Y. The responses made to Mr. Bailey's inquiries, both in numbers and completeness, reflect in no small degree the interest which the subject now excites in the minds of water-works officials. The replies are also a gratifying example of the spirit of co-operation which exists among the more intelligent and specially-trained class of municipal officials.

The important results of Mr. Bailey's work are condensed in a half-dozen lines, showing that the average daily per capita water consumption of 134 cities was 137 gallons; that those having less than 10 per cent. of their taps metered consumed 153 gallons; while the average per capita consumption where over 50 per cent. of the taps were metered was only 62 gallons, or 45 per cent. of the average for the whole 134 cities.

Some comparison between conditions existing in 1900 and 1890 may be interesting and profitable. In our issue of Jan. 16, 1892, we published statistics showing the consumption of water and use of meters in the 50 largest cities of the United States, and in all other communities having 50 per cent. or more of their taps metered.* In Table I., herewith, we have compared these earlier figures with those given in Mr. Bailey's article, stopping, however, with the 50 largest cities in the 1890 list. The final column of the table gives the increase or decrease in per capita consumption during the ten years from 1890 to 1900.

Perhaps it should be pointed out that the figures for consumption ought not to be compared in too great detail, since all the 1890 averages of consumption were based on the total populations of the respective cities, while Mr. Bailey used, for his computations, the actual populations supplied, when reported; otherwise, the 1900 census figures. Mr. Bailey was justified in this, since he contents himself with giving the actual figures reported and a few broad generalizations, based on averages. Notwithstanding the possible discrepancies named, it seemed desirable to place the two sets of figures side by side, for comparison, with the suggestion that the warning here given be kept in mind. A reference to Mr. Bailey's Table I. will show whether his per capita consumption is based on the 1900 census or the estimated population supplied. Perhaps the most notable instance of the difference in results obtained by the two methods is shown by St. Louis. According to our Table I., its per capita consumption increased from 72 to 159 gallons, in the ten years, from 1890 to 1900. But Mr. Bailey's report from St. Louis placed the population supplied at 400,000, while the 1900 census showed a total population of 575,200. Using the latter figure as a divisor, the per capita consumption in St. Louis for 1900 was 110 gallons, or an increase of 53 per cent. over 1890, instead of 120 per cent. Even the 53 per cent. is bad enough. It is to be accounted for, at least in part, by a diminution of the percentage of taps metered, which was 8.2 in 1890, and 6.3 in 1900. The same sort of calculation helps to explain why a marked increase in the use of meters at Columbus, O., from 6.4 to 34.0 per cent., should be accompanied with an increase in consumption from 78 to 230 gallons, or nearly 200 per cent. The report sent to Mr. Bailey from Columbus gave the population supplied as 100,000; the total population in 1900 was 125,560. On the latter basis, the per capita consumption becomes 183 gallons. In addition to this, the 1900 returns show that there was one tap in use for every 8.6 consumers, whereas the consumers per tap in 1890 averaged 11.5. In other words, using the total population in 1890 to find the per capita consumption was more misleading than in 1900, since relatively fewer people were supplied with water then. Thus the wisdom of using the actual population supplied, when you can get it, is emphasized. On the other hand, it is evident that the round 100,000 population in Mr. Bailey's table is merely a local guess, and by adopting such guesses for some cities and using total populations for others, where guesses are perhaps more needed, it is questionable whether the comparative value of the figures is made greater than when total population is used. This is particularly true in a census year. At other times, all the populations are guesses. If an estimate of the population actually supplied is needed anywhere it is in the case of New Orleans. No such estimate was reported, so Mr. Bailey used the total population, thus showing an apparent consumption of 48 gallons per capita in a city having but 0.4 per cent. of its taps metered. In justice to Mr. Bailey, we again call attention to the fact that his main idea was to secure broad general averages, which may be but little affected by the above considerations. Probably there is is not another large city in the United States where so small a proportion of the population uses the public water supply. When the city regains control of the works, and installs a purification plant in accordance with the teachings of the investigations it now has under way, probably the people will go back from their cisterns to the public water supply which so many of them abandoned years ago on account of its muddiness.

Leaving these details and possible discrepancies, one may find plenty of instruction from the broad general teachings of the comparative figures. As a rule, the cities that show the greatest increase in consumption also show but little increase in relative number of meters used, while many of the notable, and some of the small increases in meter percentages are accompanied by notable decreases in consumption. The five cities with decreased consumptions have each made decided gains in the percentages of taps metered.

To make it still more evident that, as a rule, cities with high consumption employ but few meters, the figures for both 1890 and 1900, given in Table I., have been rearranged in Table II., in order of consumption per capita, greatest to least. It will be noticed that in 1890 all the cities, with one exception, using over 100 gallons a day, had less than 6 per cent. of their taps metered. This exception was Milwaukee, which had 31.9 per cent. of its taps metered in 1890 and stood No. 17 in the list. In 1900, Milwaukee had 67.6 per cent. of its taps metered; its consumption had fallen to 80 gallons, and its rank to No. 37. It is very significant that the list for 1900 shows 28 cities with a consumption of 100 gallons and more per capita, against 18 in 1890, notwithstanding the marked increase in the use of meters in some of these cities. What the increase in the number of cities using more than 100 gallons a day would have been without the added percentage of meters, and what it might have been had meters been used more freely, one can only conjecture. Looked at another way, it may be seen, in the 1900 list, that of 18 cities having a consumption below 100 gallons per capita, 13 have over 20 per cent. of their taps metered.

It is gratifying to note that in more than half the cities shown in Mr. Bailey's Table I. the meters are furnished by the water department, and that in quite a number of additional cities the department supplies a part of them. As the practice of furnishing, setting and repairing water meters by the department, rather than the consumer, increases, the public prejudice against meters will also decrease. The charging of meters, in liberal numbers, to capital account will diminish the capital account for reservoirs, pumps, and mains, and this saving will in most cases far more than offset the investment in meters.

*Based on figures given in "The Manual of American Water-Works for 1891." The article in question will be found, also, in the Introduction to the "Manual" for the year named.

TABLE I.—Percentage of Taps Metered and Per Capita Water Consumption in the 50 Largest Cities of the United States in 1890 and in 1900, Arranged in Order of Population.*

| Cities. | Per cent. taps metered. 1890. | Per cent. taps metered. 1900. | Per capita consumption. 1890. | Per capita consumption. 1900. | Increase or dec., consumption, in 10 years, galls. |
|---|---|---|---|---|---|
| 1. New York.† | 20.2 | ... | 70 | 116 | + 37 |
| 2. Chicago | .... | 3.3 | 140 | 190 | + 50 |
| 3. Philadelphia. | 0.3 | 0.5 | 132 | 229 | + 97 |
| 4. Brooklyn.† | 2.5 | ... | 72 | ... | ... |
| 5. St. Louis | 8.2 | 6.3 | 72 | 159 | + 87 |
| 6. Boston | 5.0 | 5.5 | 80 | 143 | + 63 |
| 7. Baltimore | 0.1 | 1.5 | 94 | 97 | + 3 |
| 8. San Francisco. | 41.4 | 23.0 | 61 | 73 | + 12 |
| 9. Cincinnati | 4.1 | 7.6 | 112 | 121 | + 7 |
| 10. Cleveland. | 5.8 | 4.9 | 103 | 159 | + 56 |
| 11. Buffalo | 0.2 | 1.6 | 186 | 233 | + 47 |
| 12. New Orleans | 0.4 | ... | 37‡ | 48‡ | + 11 |
| 13. Pittsburg | 0.2 | 0.6 | 144 | 231 | + 87 |
| 14. Washington. | 0.3 | 2.7 | 158 | 185 | + 27 |
| 15. Detroit | 2.1 | 10.0 | 161 | 146 | — 15 |
| 16. Milwaukee | 31.9 | 67.6 | 110 | 80 | — 30 |
| 17. Newark | 2.4 | 21.9 | 76 | 94 | + 18 |
| 18. Minneapolis | 6.3 | 27.5 | 75 | 93 | + 18 |
| 19. Jersey City | 1.2 | 2.0 | 97 | 160 | + 63 |
| 20. Louisville | 5.9 | 7.5 | 74 | 100 | + 26 |
| 21. Omaha | 19.4 | 34.6 | 94 | 176 | + 82 |
| 22. Rochester | 11.4 | 25.3 | 66 | 83 | + 17 |
| 23. St. Paul | 4.2 | 28.2 | 60 | 67 | + 7 |
| 24. Kansas City | 17.6 | 40.0 | 71 | 62 | — 9 |
| 25. Providence | 62.4 | 82.6 | 48 | 54 | + 6 |
| 26. Denver | 0.8 | 1.2 | .. | 300 | ... |
| 27. Indianapolis | 7.6 | 6.0 | 71 | 79 | + 8 |
| 28. Allegheny | 0.0 | ... | 238 | ... | ... |
| 29. Albany | 0.4 | 12.3 | .. | 191 | ... |
| 30. Columbus | 6.4 | 34.0 | 78 | 230 | + 152 |
| 31. Syracuse | 14.6 | 47.3 | 68 | 102 | + 34 |
| 32. Worcester | 89.4 | 94.3 | 59 | 70 | + 11 |
| 33. Toledo | 9.4 | 50.3 | 72 | 119 | + 37 |
| 34. Richmond | 1.4 | 30.4 | 167 | 100 | — 67 |
| 35. New Haven | ... | 2.6 | 135 | 150 | + 15 |
| 36. Paterson | ... | 20.7 | 128 | 129 | + 1 |
| 37. Lowell | 22.9 | 52.5 | 66 | 85 | + 19 |
| 38. Nashville | 0.8 | 41.5 | 146 | 140 | — 6 |
| 39. Scranton | ... | ... | .. | .. | ... |
| 40. Fall River | 74.6 | 94.3 | 29 | 36 | + 7 |
| 41. Cambridge | 2.4 | 6.1 | 64 | 79 | + 15 |
| 42. Atlanta | 89.6 | 91.6 | 36 | 84 | + 48 |
| 43. Memphis | 3.7 | 8.3 | 124 | 125 | + 1 |
| 44. Wilmington | 0.2 | 4.3 | 113 | 90 | — 23 |
| 45. Dayton, | 3.8 | 46.7 | 47 | 62 | + 15 |
| 46. Troy | 3.9 | 4.2 | 125 | 183 | + 58 |
| 47. Grand Rapids. | ... | 13.4 | .. | 156 | ... |
| 48. Reading | 0.1 | 4.0 | 75 | 92 | + 17 |
| 49. Camden | ... | 1.4 | 131 | 280 | + 149 |
| 50. Trenton | ... | ... | 62 | 99 | + 37 |

*The classification is by the census of 1890, so as to include all the cities in the earlier grouping.
†New York and Brooklyn consolidated since 1890.
‡Only a small part of the population supplied.

TABLE II.—Water Consumption and Percentage of Taps Metered in 50 Largest Cities of the United States, Arranged in Order of Consumption.*

| In 1890. Rank. | City. | Consumption, galls. | P. ct. taps metered | In 1900. Rank. | City. | Consumption, galls. | P. ct. taps metered |
|---|---|---|---|---|---|---|---|
| 1. | Allegheny | 238 | 0.0 | 1. | Denver.† | 300 | 1.2 |
| 2. | Buffalo | 186 | 0.2 | 2. | Allegheny | ? | ? |
| 3. | Richmond | 167 | 1.4 | 3. | Camden | 280 | 1.4 |
| 4. | Detroit | 161 | 2.1 | 4. | Buffalo | 233 | 1.6 |
| 5. | Washington | 158 | 0.3 | 5. | Pittsburg. | 231 | 0.6 |
| 6. | Nashville | 146 | 0.8 | 6. | Columbus | 230 | 34.0 |
| 7. | Pittsburg. | 144 | 0.2 | 7. | Philadelphia | 229 | 0.5 |
| 8. | Chicago | 140 | ... | 8. | Albany | 191 | 12.3 |
| 9. | New Haven | 135 | ... | 9. | Chicago | 190 | 3.3 |
| 10. | Philadelphia. | 132 | 0.3 | 10. | Washington. | 185 | 2.7 |
| 11. | Camden | 131 | Small | 11. | Troy. | 183 | 4.2 |
| 12. | Paterson | 128 | Small | 12. | Omaha. | 176 | 34.6 |
| 13. | Troy. | 125 | 3.9 | 13. | Jersey City | 160 | 2.0 |
| 14. | Memphis | 124 | 3.7 | 14. | St. Louis | 159 | 6.3 |
| 15. | Wilmington | 113 | 0.2 | 14. | Cleveland | 159 | 4.9 |
| 16. | Cincinnati | 112 | 4.1 | 15. | Grand Rapids. | 156 | 13.4 |
| 17. | Milwaukee | 110 | 31.9 | 16. | New Haven. | 150 | 2.6 |
| 18. | Cleveland | 103 | 5.8 | 17. | Detroit. | 146 | 10.0 |
| 19. | Jersey City | 97 | 1.2 | 18. | Boston | 143 | 5.5 |
| 20. | Baltimore | 94 | 0.1 | 19. | Nashville | 140 | 41.5 |
| 20. | Omaha | 94 | 19.4 | 20. | Paterson | 129 | 20.7 |
| 21. | Boston | 80 | 5.0 | 21. | Memphis | 125 | 8.3 |
| 22. | New York | 79 | 20.2 | 22. | Cincinnati | 121 | 7.6 |
| 23. | Columbus. | 78 | 6.4 | 23. | Toledo | 119 | 50.3 |
| 24. | Newark | 76 | 2.4 | 24. | New York | 116 | ... |
| 25. | Reading | 75 | 0.1 | 25. | Syracuse | 102 | 47.3 |
| 26. | Minneapolis | 75 | 6.3 | 26. | Richmond. | 100 | 30.4 |
| 26. | Louisville | 74 | 5.9 | 26. | Louisville | 100 | 7.5 |
| 27. | Toledo | 72 | 9.4 | 27. | Trenton | 99 | ... |
| 27. | Brooklyn | 72 | 2.5 | 28. | Baltimore | 97 | 1.5 |
| 27. | St. Louis | 72 | 8.2 | 29. | Newark | 94 | 21.9 |
| 28. | Indianapolis | 71 | 7.6 | 30. | Minneapolis | 93 | 27.5 |
| 28. | Kansas City | 71 | 17.6 | 31. | Reading | 92 | 4.0 |
| 29. | Syracuse | 68 | 14.6 | 32. | Wilmington | 90 | 4.3 |
| 30. | Lowell | 66 | 22.9 | 33. | Lowell | 85 | 52.5 |
| 30. | Rochester | 66 | 11.4 | 34. | Atlanta | 84 | 91.6 |
| 31. | Cambridge | 64 | 2.4 | 35. | Rochester | 83 | 25.3 |
| 32. | Trenton | 62 | Small | 36. | Milwaukee | 80 | 67.6 |
| 33. | San Francisco | 61 | 41.4 | 37. | Cambridge | 79 | 6.1 |
| 34. | St. Paul | 60 | 4.2 | 37. | Indianapolis | 79 | 6.0 |
| 35. | Worcester | 59 | 89.4 | 38. | San Francisco | 73 | 23.0 |
| 36. | Providence | 48 | 62.4 | 39. | Worcester | 70 | 94.3 |
| 37. | Dayton | 47 | 3.8 | 40. | St. Paul | 67 | 28.2 |
| 38. | New Orleans | 37 | 0.4 | 41. | Kansas City | 62 | 40.0 |
| 39. | Atlanta | 36 | 89.6 | 42. | Dayton | 62 | 46.7 |
| 40. | Fall River | 29 | 74.6 | 43. | Providence | 54 | 82.6 |
| | | | | 44. | New Orleans | 48 | ... |
| | | | | 45. | Fall River. | 36 | 94.3 |

*A few cities are omitted from each list, on account of missing figures. This table is based on Table I., which in turn was based on the classification of the census of 1890, instead of that of 1900.
†In Denver, water is used for irrigation.

# LETTERS TO THE EDITOR.

## Comparative Use of Prismoidal Formula and Average End Area Method of Computing Earthwork.

Sir: Referring to a query made by "Average Area," Buffalo, N. Y., in Engineering News of March 21, 1901.

During the experience of the writer in the past 14 years in Colorado, Montana, Idaho, Utah and Nevada on railroad, mining and irrigation work, he has never found use for the prismoidal formula, or the application of a prismoidal correction to earthwork calculations. His experience would lead him to suppose that practically all of the earth and rock work carried on in this country is calculated and paid for on the basis of averaged end areas.

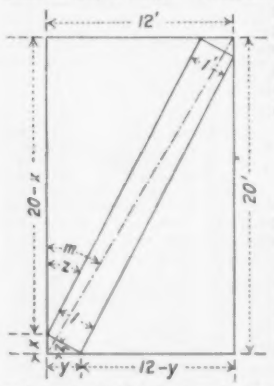
In fact, it would seem folly to waste time and money in applying a prismoidal correction to calculations based upon cross-section notes taken in the field by reading the level rod to the nearest tenth of a foot. In mountainous country a very slight movement of the rod either to the right or the left would, perhaps, change the elevation of the point in the cross-section several tenths of a foot without appreciably changing the other co-ordinate of the point. On mountain railroad work, over rough and broken country, with outcropping ledges of rock, or along steep and irregular hillsides, the adjustment of a cross-section so that all parties concerned may get that which belongs to them, is something of an art; and the exercise of judgment born of experience, on the part of the engineer or his rodman, is more important than the working out of an exact mathematical proposition or the practice of a theoretic science.

If a piece of country were made up of hills, slopes and valleys all having perfectly smooth and firm surfaces, then, and then only would it appear rational for one to go into such delicately adjusted theoretic methods of work, as to read the level rod in the taking of cross-section notes to hundredths or thousandths of a foot, and the application of the prismoidal correction to the result of the calculations of the cubical contents; then, also, it might be well to carry the calculations out to some four or five places of decimals. However, it has never been my fortune or misfortune to be called upon to execute work in a country constructed on the above-mentioned plan.

Very truly yours, O. O. McReynolds,
Assoc. M. Am. Soc. C. E.
Chief Engineer Twin Lakes Land & Water Co.
Nepesta, Colo., April 9, 1901.

## The Howe Truss-Brace Problem.

Sir: I submit the following solution of the Howe truss-brace problem. While it may not be new to some, I have never as yet seen it in print, and I have found it very simple and a solution which will give quick and close results. In the accompanying figure let us suppose that the depth of the panel = 20 ft.; panel length = 12 ft., and width of strut, or brace, = 1 ft.; and x and y the co-ordinates of end of brace. Problem: To find the angle z and the length of brace. Now, if the angle m were the angle required the calculation would be very simple as:




Nat. tang angle m

$$= \frac{12}{20} = 0.60000$$

$$= 30° 58',$$

which let us consider to be a rough approximation to the angle z.

By geometry the angle z equals the angle $z_1$, and if we assume, for the sake of calculation, that

angle m = z = $z_1$,

and from a table of natural sines and cosines take out the sine and cosine of m (now assumed equal to $z_1$) it will give us an approximation of the values of x and y, which if afterwards we subtract from 20′ and 12′ respectively, will give us very nearly the required lengths of the sides of the triangle required to be solved. For example:

First approximation:

m = 30° 58′. Assuming m = z = $z_1$

then

cos $z_1$ = y, and sin $z_1$ = x.

Take from a table of natural sines and cosines,

cos $z_1$ = y = 0.85747; sin $z_1$ = x = 0.51454.

Now from Fig. 1,

$$\frac{12 - y}{20 - x} = \text{nat. tang of z or } z_1. \qquad (1)$$

Solving

$$\frac{12 - y}{20 - x} = \frac{11.14252}{19.48546} = \text{nat. tang of z or } z_1$$

$$= 0.57183 = 29° 46'; \quad \therefore \ z = z_1 = 29° 46'.$$

Second Approximation.—We have from the first approximation $z_1$ = 29° 46′. Now cos $z_1$ = y = 0.86805, and sin $z_1$ = x = 0.49647.

Again, by using formula (1) we have:

$$\frac{12 - y}{20 - x} = \frac{11.13195}{19.50353} = \text{nat. tang } z_1 = 0.57076 = 29° 43'$$

$$\therefore \ z = z_1 = 29° 43'.$$

Third Approximation.—We have again from second approximation: z = $z_1$ = 29° 43′; then cos $z_1$ = y = 0.86849; sin $z_1$ = x = 0.49571. Again using formula (1) we have:

$$\frac{12 - y}{20 - x} = \frac{11.13151}{19.50429} = \text{nat. tang } z_1 = 0.57072 = 29° 43'$$

$$\therefore \ z = z_1 = 29° 43',$$

the same result as found by the second approximation, and

x = 0.49571; y = 0.86849;

so that practically speaking the second approximation will give the value of z to all intents and purposes.

The above can be easily proved by the equation

$$\sqrt{x^2 + y^2} = 1,$$

x = 0.49571 $x^2$ = 0.24571
y = 0.86849 $y^2$ = 0.75429

$$\therefore \ x^2 + y^2 = 1.00000$$

$$\text{The length of brace} = \frac{12 - y}{\sin z} = \frac{11.13151}{\sin 29° 43'} = 22.455.$$

If the width of the brace varies from the above; that is to say, is greater or less than 1, as it very likely will be, it will be necessary in each instance to multiply the sine and cosine of $z_1$ by the width of the brace (radius), for the value of x and y, before proceeding as above with the calculation.

Yours very truly,
Matthew H. McGee.

Kingston, N.Y., March 27, 1901.

Sir: Mr. Frye's method of computing angles for Howe truss braces is interesting and ingenious. I would offer two other schemes though I dare say both of them are old.

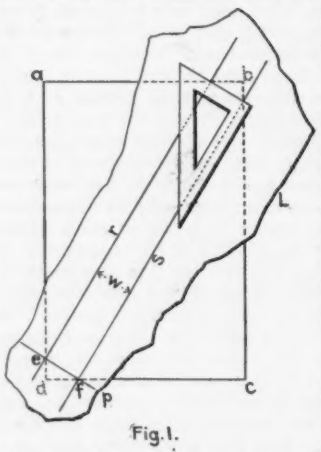


Fig. 1.

Draw the rectangle a b c d to scale, and on a piece of tracing linen L, draw two parallel lines r and s, distance w apart, where w = the width of the brace. Draw a perpendicular p across them, intersecting at e and f.

Now lay the cloth on the figure previously drawn in such a position that the points e and f fall on the sides of the rectangle. By laying a set square on the lines at the other corner it may be seen at once when the intersections there come opposite one another. Then prick the points through. If carefully done the method is sufficiently accurate for practical purposes.

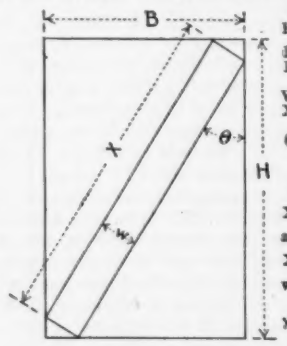


Fig. 2.

Also the following: In Fig. 2 let

H = height;
B = breadth of rectangle;
W = thickness of brace;
X = length of brace; and,
θ = angle between the brace and vertical.

Now,

X cos θ + W sin θ = H,

and

X sin θ + W cos θ = B;

whence

$$X = \frac{H - W \sin \theta}{\cos \theta} = \frac{B - W \cos \theta}{\sin \theta}; \qquad (1)$$

$$\therefore \ B \cos \theta - H \sin \theta = W \cos 2\theta. \qquad (2)$$

If H is greater than B, $\frac{B}{H}$ = tangent of an angle slightly greater than θ, and from this we can make a close approximation to the true angle by means of equation (2); then X is found from equation (1).

By the use of a slide-rule this may be done very quickly; especially if the graphical method be used first as a basis on which to work. Yours very truly,

R. K. Palmer.

Hamilton, Canada, Mar. 4, 1901.

## Notes and Queries.

J. O. E., New York City, writes:

For the benefit of about 20 engineers, including myself, will you kindly describe a "plunge-rod" and the operation of "plunging a grade?" We have sought (dictionaries, catalogues, reference works, etc.) in vain, yet it is frequently used in examinations.

We give it up and pass the query on to our readers.

Apropos of the note on page 212 of our issue of March 28, describing the starting of a Snow duplex pump at Leadville, Colo., submerged under 80 ft. of water, we have received the following from the Union Steam Pump Co., of Battle Creek, Mich.:

One of our Moore sinking pumps (sold from our Denver depot) was found this spring to be submerged 175 ft. Steam was turned on and the pump cleared itself and pumped the shaft out without trouble.

CIVIL SERVICE EXAMINATIONS for positions in the engineering force of the U. S. Navy Department will be held at the Navy Yard, New York, April 30, 1901. The examinations will be held for the following positions: Department of Construction and Repair, one first-class ship draftsman, $5.04 per day. Department of Yards and Docks, two first-class structural steel-work draftsmen, $5.04 per day. Department of Equipment, one third-class electrical draftsman, $4.48 per day; one first-class assistant electrical draftsman, $4 per day; one second-class assistant electrical draftsman, $3.76 per day; one third-class assistant electrical draftsman, $3.52 per day; one first-class copyist electrical draftsman, $3.28 per day. The examination will be open to all comers who can give evidence of experience in the kind of work for which they seek employment, and who are citizens of the United States. Persons now holding positions at the yard will be admitted to competition on the same footing as other applicants. Applications will be addressed to the "Commandant, Navy Yard, New York," and must be delivered to him on or before April 29. No application received after that date will be considered. Each applicant will state in his application his name, age, residence, citizenship, present occupation, and previous employment or work done. The applications will be accompanied by evidence of citizenship, and by certificates, preferably from previous employers, as to character, habits of industry and sobriety, and skill and experience in work of the kind required. A Board of Examiners will convene at the Navy Yard, New York, on the 30th day of April or as soon after as practicable. Applicants will be informed of the date upon which they will be required to report for examination. The examination will be practical in character, having reference exclusively to the requirements of the positions to be filled. The applicant's antecedents and experience, as well as the character of his previous work, will be duly considered by the board in making its recommendations. The board will make sufficient inquiry to ascertain that the applicants recommended are fit for the work; that they have enough education to make the required reports, estimates, and calculations; that they are of reputable character, and of sober and industrious habits, and that they have not been convicted of crime or misdemeanor. Candidates passing the above examination are eligible for appointment anywhere in the naval service. There are many vacancies at present, especially for structural steel-work draftsmen.

SUBMARINE SIGNALING, on the system invented by the late Prof. Elisha Gray, was tested in Boston harbor on April 6. The purpose of the invention is to prevent danger from shipwreck or collision by enabling vessels, or a vessel and fixed land signal, to communicate. The Gray Telephone Co., with $300,000 capital, has been organized to promote the device. The outfit is simple enough. In this experiment a large bell weighing 8,000 lbs. was submerged 20 ft. deep off Deer Island, and by electric apparatus this bell was struck from a keyboard, giving forth signals according to a definite code. The receiving instrument on the vessel consists of a number of diaphragms attached to a connecting tube, and this is lowered into the water 12 to 15 ft. Connected with this was an ordinary long-distance telephone receiver, located in the pilot-house. The ringing of the bell was distinctly heard at a distance of five miles and quite clearly at ten miles. It was not explained how two vessels at sea could signal each other, but this plan is said to have been worked out.

FIVE HOLLAND SUBMARINE BOATS have been ordered by the British government and they are now being constructed by Vicker's Son & Maxim. They will be 63 ft. 4 ins. long, have 11 ft. 9 ins. seam, with a submerged displacement of 120 tons. Power will be furnished by a 160-HP. gasoline engine and enough fuel will be carried for a run of 400 knots. The surface speed will be nine knots and the submerged speed with the electric motor will be 7 knots. A torpedo tube will be placed in the bow of the vessel and five torpedoes will be carried.

ANOTHER COMBINED GARBAGE FURNACE and electric lighting plant for Chicago has been recommended by a committee of the city council. The plant would have a daily capacity of 100 tons of garbage and other refuse and would be located on land owned by the city, at the House of Correction. Mr. W. F. Brennan is chairman of the committee.

THE SUPPRESSION OF THE SMOKE NUISANCE is being attempted in Boston, and the Mutual Boiler Insurance Co., of that city, is co-operating. A circular sent out by that company affirms that this smoke is due to the misuse of coal, or loss of heat from bad methods of firing, or is caused by a defective or over-worked steam plant. It holds that the most effective smoke consumer in a small steam plant is a skillful and well-paid fireman. A list of questions has been sent out to coal consumers, bearing upon this subject; and it is believed that by collating the information thus obtained some general principles may be deduced that will be useful.

THE WORLD'S CONSUMPTION OF COPPER in 1900 is reviewed by James Lewis & Son, of Liverpool, as follows: The consumption for 1900 was abnormally large; the total European increase over the previous year was about 38,500 tons, and that of the United States was 23,500 tons, or a total increase of 62,000 tons. This increase is mainly due to the development of electric power; though the demand for ammunition has also been large, and the use of copper for the manufacture of sulphate absorbed 5,000 tons more in the United States than in 1899, 25,000 tons being now annually consumed for this purpose; exports from the United States increased 42,334 tons, while that from Europe into England decreased 20,215 tons. The total increase in production in North America and from other sources was about 25,500 tons. Judging from the reduction in the English, French and American stocks on hand, the consumption of copper in 1900 exceeded the production by 17,690 tons, and this consumption is likely to continue during the present year. The reviewer doubts whether the production will keep pace with the promised increase in consumption.

THE CAPE-TO-CAIRO TELEGRAPH LINE, says the "Zeitung des Ver. Eisenbahn Veraaltungen," for Jan. 12, will be 5,580 miles long, and of this total 2,976 miles are constructed from the Cape northward, and 1,736 miles are finished at the Egyptian end, leaving only 868 miles to be built. The establishment of this line has been very difficult, as long sections of it pass through virgin forests; and it will be troublesome to protect from the raids of savages upon the wire. It is said that the rate per word for transmission will be about 92 cts.; or, practically the same as the cost of telegraphing from the Cape to England.

## CONVERSAZIONE OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

A novel and very successful entertainment was given by the American Institute of Electrical Engineers on the evening of April 12, in the lecture halls and laboratories of Columbia University, in New York city. The latest electrical inventions and devices were exhibited in operation, and lectures on the various exhibits were delivered by well-known inventors. Although only members of the Institute and their ladies and invited guests were admitted, Havemeyer Hall, in the auditorium of which the lectures were delivered, and the rooms of the Mechanical Laboratory, where the exhibits were placed, were almost overcrowded. However, everything was so well conducted, and the things to be seen were so interesting, that everyone was greatly pleased and entertained. An excellent collation and music added to the enjoyableness of the evening.

Although some of the exhibits were more in the domain of pure physics than in that of practical engineering, many of the devices shown were of great value and importance. We will briefly describe some of the exhibits in the order in which they were shown.

A revolving spark experiment was shown by Mr. W. S. Andrews, showing an oscillating discharge occurring rapidly during the same half wave, and demonstrating that a short circuit in a high potential system containing inductances and capacity ruptures itself instantly.

Mr. Charles L. Clarke exhibited a synchronism and phase indicator for determining when two alternators are in phase and synchronism. It may also be used for showing the phase relation of the current and electromotive force in the same circuit or of two currents in different circuits having the same periodicity. The apparatus consists of two synchronous motors, which drive stroboscopic discs. The stroboscopic image is formed opposite a scale, and indicates when the generators are in synchronism, or nearly so, and, in the latter case, which one is running at the greater polar speed. When the generators are in synchronism, the stroboscopic image is stationary, and its position relative to the scale indicates the phase difference.

The telpherage system of the United Telpherage Co., of New York city, was exhibited by Mr. A. F. Clift. This system was described in Engineering News of Feb. 7.

Mr. W. J. Hammer exhibited Prof. Langley's bolometer and a large collection of balloon photographs. He also showed some Nernst lamps in operation.

The room of the laboratory which was illuminated by Mr. Cooper Hewitt's system of vacuum tube lighting was crowded with people curious to see the "artificial sunlight." The light was extremely flickering and disagreeable, and by it the face and hands appeared ghastly purple.

Another exhibit which attracted much attention was Mr. M. R. Hutchinson's micro-telephonic apparatus for deaf persons. It consists of a loud-speaking receiver, which is fitted over the patient's ear and a microphone or transmitter into which a person may talk or which may be fitted to a phonograph. The apparatus has been very successfully used in the instruction of deaf mutes. A number of pupils from a school for deaf mutes in New York city were present, one of whom had received only five hours' instruction and could already pronounce quite plainly a number of words.

Mr. F. A. Laws had on exhibition an apparatus which could be used for obtaining radiographs of alternating current wave forms. In its working it depends upon the fact that Roentgen rays are deflected by a magnetic field. In this way a spot of light produced by the rays upon a screen may be caused to move in accordance with the magnetic field set up by an alternating current.

A teleautograph, or picture telegraph, was shown in operation, working between Columbia and Chicago Universities, by Mr. H. R. Palmer. The picture to be sent is first transferred to a sheet, which is wrapped around a cylinder, upon which a stylus presses. This cylinder revolves in synchronism with one at the receiving station, upon which a sheet of paper is wrapped. A second stylus marks upon the latter and is controlled in its motion by the first stylus.

Prof. M. I. Pupin placed on exhibition the apparatus used by him in developing his recent inventions for the improvement of long distance telephony. A short account of his inventions was published in the issue of Engineering News for Aug. 23, 1900.

A copper splicing machine was shown by Mr. H. F. Sanville. It consisted of a small hydraulic press capable of giving a pressure of 40 tons. The two ends of the cable to be spliced were placed together within a copper sleeve, and the whole joint was then subjected to great pressure.

Other exhibits were as follows: faradmeter and bridge, by E. V. Baillard; magnetic liquids, by F. B. Crocker; incandescent lamp experiments, by Wm. E. Geyer; Gould storage battery, by W. W. Donaldson; electric furnace, Holtz machine and ohm-meter, by Otto T. Louis; storage battery, by Messrs. Perret, Barrett and Meadowcroft; wireless telegraph and army telephone outfit, by Capt. Samuel Reber; wave form indicator and frequency indicator, by Mr. Robinson; alternation meter, phase shifting transformer, power factor indicator, etc., by Charles F. Scott; dynamo static machine, electric gyroscope and Bohnenberger sphere, by Prof. Elihu Thompson; wave tracer, by Fitzhugh Townsend.

## BOOK REVIEWS.

THE GAS-ENGINE HANDBOOK.—A Manual of Useful Information for the Designer and the Engineer. By E. W. Roberts, M. E. 2d ed. Cincinnati: The Gas Engine Pub. Co. 3½ × 5¼ ins.; pp. 241; 40 illustrations. Cloth, $1.25; leather, $1.50.

This modest little book is deserving of high praise. The author tells us in his preface that he was led to its preparation by his work upon a series of text books on gas engines for the International Correspondence Schools, in the course of which he discovered the scarcity of really first-rate and up-to-date literature representative of American gas-engine practice. He has written a book which should be of value to every engineer who has anything to do with gas engines, either as a designer, salesman or attendant. The book is not an elaborate treatise, of course, like the works of Clerk and Robinson, but it is a practical handbook, and will be more useful by far to the gas-engine attendant than the more elaborate and more expensive works, and will be at least equally valuable, we believe, to the engineer undertaking gas-engine design.

THE GAS AND THE WATER-WORKS DIRECTORY AND STATISTICS, 1900-1 (Revised to August, 1900.) With a List of Chairmen, Managers, Engineers and Secretaries, and Lists of Associations of Engineers and Managers. London: Hazell, Watson & Viney. Cloth; 6 × 9 ins.; pp. 378 and 151. Price, 10 shillings in Great Britain; $4 in the United States, or, separately, 6 shillings, and $2.40, respectively.

There are here given in one volume the usual range of statistical and other information presented in the two annuals, on gas and on water-works, respectively, which we have favorably noticed in previous years. The works covered are located in Great Britain and Ireland, with the exception of such foreign corporations as have offices in London. The water-works section follows much the same general plan, only with less detail, as our "Manual of American Water-Works," while the section on gas-works is quite like, only fuller, Brown "Directory of American Gas Companies."

A TREATISE ON HIGHWAY CONSTRUCTION. Designed as a text-book and work of reference for all who may be engaged in the location, construction or maintenance of roads, streets and pavements. By Austin T. Byrne, C. E. Fourth revised and enlarged edition. New York: John Wiley & Sons. Cloth; 5¾ × 9 ins.; pp. 895; illustrated. $5.00.

The practical value of this work has been tested by the demand for a fourth edition. And to keep the volume abreast of the times, its contents have been thoroughly revised and about 125 pages of new matter have been added; the chief expansion being in the chapters devoted to the various types of street pavements, including tables of asphalt production and manufacture and the comparative cost of laying and maintaining pavements in American and European cities.

POLYPHASE ELECTRIC CURRENTS AND ALTERNATE CURRENT MOTORS.—By Silvanus P. Thompson, D.Sc., Principal and Professor of Physics in the City and Guilds of London Technical College. Second and enlarged edition. New York: Spon & Chamberlain. London: E. & F. N. Spon. Cloth; 6 × 9 ins.; pp. 508; 351 figures with eight folding plates. $5.00.

Prof. Thompson's treatise on "Dynamo-Electric Machinery" is widely and favorably known for both its completeness and lucidity of treatment of all subjects connected with direct and single-phase alternating current machinery. The present volume covers the field of polyphase working in an equally satisfactory manner. The author commences with a thorough and lucid discussion of the principles of alternating currents, after which he describes and illustrates the methods of construction adopted by the principal European and American manufacturers. A notable feature of this edition of the book is the large number of diagrams of windings for polyphase machines, in which the several circuits are printed in different colors, making them easily distinguishable. Another useful addition is an appendix containing a list of all the British patents on alternating current devices. Another appendix explains the symbolic method of calculating alternating currents. The titles of some of the chapters of the book are as follows: Combination of Polyphase Currents and Economy of Copper; Examples of Polyphase Generators; Graphic Theory of Polyphase Motors; Single-Phase Motors; Polyphase Transformers and Phase Transformation; Polyphase Equipment of Factories; Polyphase Electric Railways. For the engineer who wishes to obtain a clear and comprehensive view of the present state of the art this is probably the best treatise published.

IRON CORROSION.—Anti-Fouling and Anti-Corrosive Paints. By Louis Edgar Andes, author of "Animal Fats and Oils," "Vegetable Fats and Oils," etc. Translated from the German by Charles Salter. London: Scott, Greenwood & Co. New York: D. Van Nostrand Co. Cloth; 6 × 8½ ins.; pp. 275; illustrated. $4.

There is an urgent demand among American engineers for a thoroughly reliable and up-to-date treatise on paints and painting, covering especially the protection of iron structures from corrosion. We had strong hopes from the neat external appearance of the volume before us that it was destined to fill this long-felt want. We are obliged to say, however, that its contents do not satisfy the expectations raised by its good binding. The book does, indeed, contain a large amount of information on the subject indicated by its title, but it is arranged in so unsystematic a manner that its usefulness is much impaired. There is no division of the work into chapters, and such classification of its contents as has been made is very crudely done. For example, under the head of "carbon," a part of a page is devoted to graphite, with no mention at all of lampblack. Naturally, the work treats of German practice almost exclusively, and a very large part of the book is made up of direct quotations from such German writers as Spennrath, Simon, Mulder, Landolt and others. So liberal are these quotations that the book may almost be called a compilation rather than an original treatise. It is fair to say, however, that the quotations appear to be well chosen, and from competent and reliable authorities, most of whom are quite inaccessible to the ordinary American engineer.

With all its defects, the book is entitled to rank, we believe, as the best work that has thus far appeared upon this important subject. The information presented appears to be reliable and unbiased. Some of the widely advertised claims for particular paints are thoroughly exposed by the author, and we have discovered nowhere any evidence of partiality toward particular interests.

## A DECISION OF THE SUPREME COURT OF WISCONSIN AGAINST WATER POLLUTION.

The Supreme Court of Wisconsin has followed the precedent established by the courts of last resort in a number of other states in deciding that the pollution of inland waters by the sewage of cities is an infringement of private rights and a transgression against public sanitation which cannot be tolerated. A suit was brought against the city of Waukesha, Wis., by Mrs. Martha Winchell, who owns a farm on the Fox River, asking for an injunction against the further discharge of sewage into the river, and for damages on account of the pollution already suffered.

The County Court, on Nov. 12, 1900, ordered the city to stop discharging its sewage into the stream, and also granted permission for a jury trial to assess damages to the plaintiff. On April 9, 1901, the Supreme Court affirmed the decision, with the modification that the city might continue to discharge sewage into the river if the sewage:

shall have first been so deodorized and purified as not to contain foul, offensive or noxious matter capable of injuring the plaintiff or her property or causing a nuisance thereto.

The opinion of Judge Dodge in this case contains such reasonable statements on the subject of water pollution that we are pleased to give space to the following extract:

We cannot but recognize that as the density of our population increases, as our citizens engage in new and greater industries, and as the municipal aggregations of population multiply and expand, the original purity of streams and water basins cannot be wholly preserved. They are the natural and unavoidable courses and receptacles of drainage, through and into which must flow the refuse of human habitation and industry. How far these changing conditions must bring about a yielding of the private rights of continued purity of those lakes and streams to the necessity of use thereof for the public and general health and convenience, and upon what terms such yielding shall come, are primarily questions of policy for the legislature, within the limits of its power over private rights defined by the constitution. When, if ever, the legislature shall enact that streams generally or any streams shall be used as sewers without liability to the owners of the soil through which they run, the question of constitutional protection to private rights may be forced upon the courts for decision. Until such enactment is made, however, in clear and unambiguous terms, we shall be slow to hold by inference or implication that it has been made at all. The right of the riparian owner to the natural flow of water substantially unimpaired in volume and purity is one of great value and which the law nowhere has more persistently recognized and jealously protected than in Wisconsin. Not alone the strictly private right, but important public interests would be seriously jeopardized by promiscuous pollution of our streams and lakes.

Amid this conflict of important rights, we cannot believe that the legislature concealed in words merely authorizing municipalities to raise and expend money for the construction of sewers, a declaration of policy that each municipality might in its discretion, without liability to individuals, take practical possession of the nearest stream as a vehicle for the transportation of its sewage in crude and deleterious condition. The authority granted to municipalities is to construct sewers, but subject to the general legal restrictions resting upon such corporations forbidding invasion of private rights by the creation of nuisance or otherwise. This view of the legislative purpose is enforced by the consideration that although liquid sewage must flow off along the general drainage courses of the vicinity, it is by no means physically necessary that it should carry with it the solids in an offensive or unhygienic condition.

We are indebted to Mr. Wm. Powrie, of Waukesha, Wis., an engineer employed by the plaintiff, for information relating to the suit and decision.

## ANNUAL REPORT OF THE STATE ENGINEER OF NEW YORK.

The report of the State Engineer and Surveyor of New York, Mr. Edward A. Bond, for the year ending Sept. 30, 1900, has just been published, several months ahead of the usual date, and it is one of the most interesting and important documents that has ever been issued from that office. One of its valuable features is a set of standard specifications used in 1900 for all work on the New York State Canals. These specifications cover masonry and its classification, concrete, Portland cement and flagging sidewalks, stone-paving, rip-rap, brick and asphalt pavement; piles, timber work and bolts; grubbing, draining, excavation, embankment and puddling work; bridge superstructure and machinery for lift and swing bridges; instructions to bidders, etc. This is an exceedingly useful series of documents, and their publication in this form will be appreciated by engineers.

The history of the state canals, in their five stages, is briefly sketched, from their origin in 1768, when Sir Henry Moore, the Colonial Governor, proposed the improvement of the Mohawk River at Canajoharie, down to the present time. The first step was taken in 1788, when Elkanah Watson proposed improving the natural channels by way of the Mohawk River to Wood Creek, and thence through Oneida Lake to the Oswego River and to Lake Ontario. By 1796 this project was so far carried out as to afford navigation, for boats carrying 16 tons, from Schenectady westward, 184 miles. The second advance was in 1808, when Simeon De Witt made a survey from the Hudson to Lake Erie, resulting in the passing of the canal law of 1816 which authorized the construction of the Erie and Champlain canals. These canals were commenced in 1817 and completed in 1825; the Lake Ontario-Oswego section being built in 1825-28. The waterway then constructed was 28 ft. wide at the bottom, 40 ft. wide at the surface and 4 ft. deep; the locks were 90 ft. long by 12 ft. wide. The Champlain Canal, however, was only 20 and 30 ft. wide and 3 ft. deep, with locks 75 × 10 ft. The third step was taken in 1835, when it was ordered that the Erie and Oswego canals should be enlarged to 52½ ft. wide at the bottom, 70 ft. wide at the surface and 7 ft. deep. The locks were made 110 ft. long by 18 ft. wide, allowing the passage of boats carrying 250 tons. This work was completed in 1862. The fourth step was suggested in 1878, when the State Engineer proposed further enlargement on what has since been known as the Seymour plan; the chief object being to increase the depth to 8 ft. by raising the banks or lowering the bottom as conditions might warrant. This step was further advanced in 1895, when the people of the state voted $9,000,000 to increase the depth to 9 ft. in the waterway and 8 ft. in the locks and aqueducts. This was the Seymour-Adams plan of 1895. The fifth stage of development is now begun by surveys and estimates made for a barge canal. At the same time the United States Deep Waterway Commission has prepared a report and estimates for a 21-ft. and a 30-ft. ship canal through the state, at a cost of $485,000 for surveys, etc. In March, 1899, Governor Roosevelt appointed an expert committee to advise as to

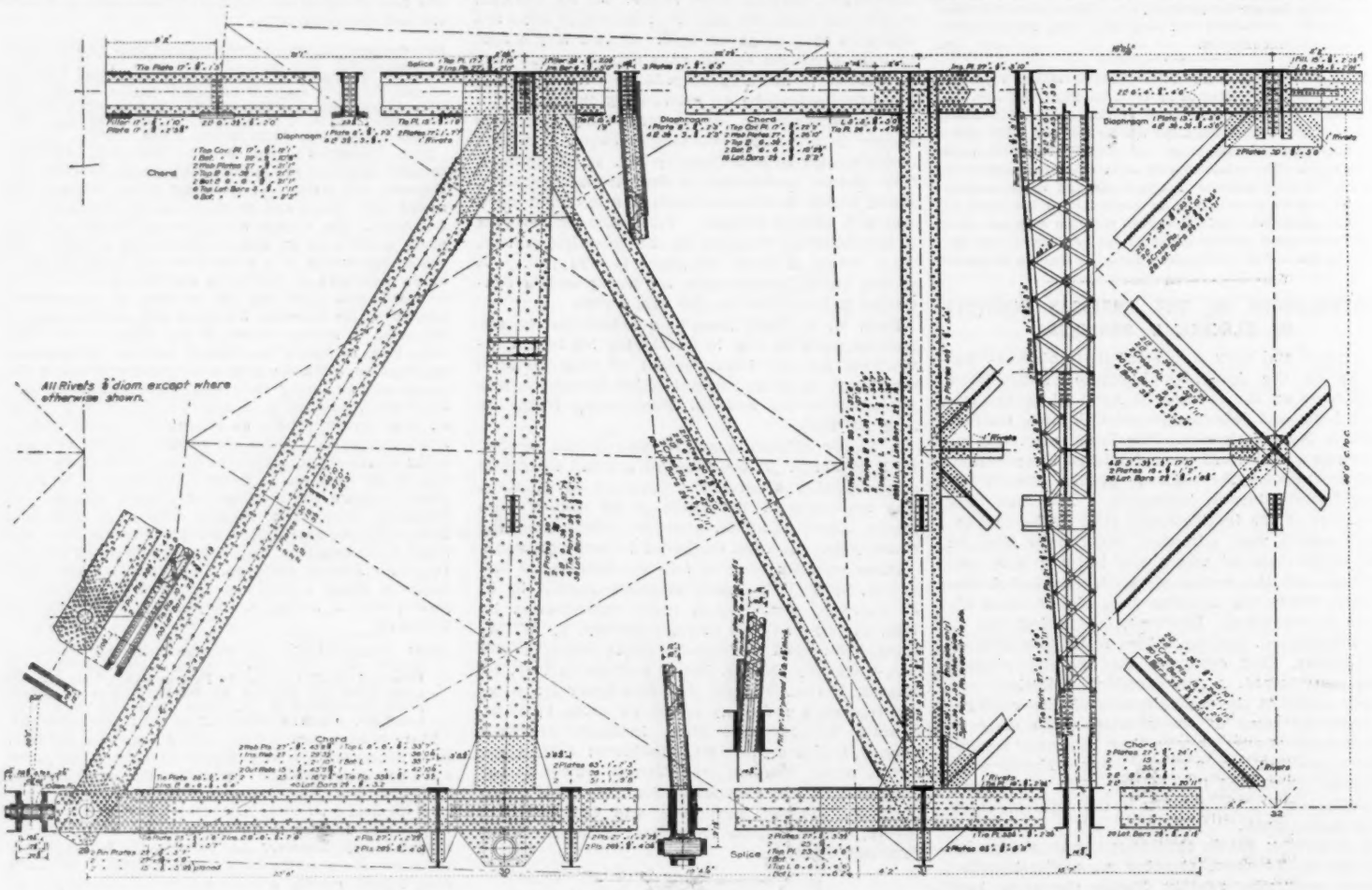



FIG. 1. DETAILS OF CANTILEVER END OF STIFFENING TRUSS NEAR MAIN TOWER; NEW EAST RIVER BRIDGE.

the policy which the state should pursue toward its canals. This committee, on Jan. 15, 1900, made a report recommending a barge canal, capable of passing boats 150 ft. long, 25 ft. wide, 10 ft. draft and carrying 1,000 tons. The estimated cost of carrying out this project was $62,000,000. The Legislature adopted this report, and on April 12, 1900, it passed a law calling upon the state engineer for new surveys of specified portions of the route; and for plans and estimates for a barge canal having not less than 12 ft. depth in the waterway, 11 ft. in the locks and aqueducts, with locks

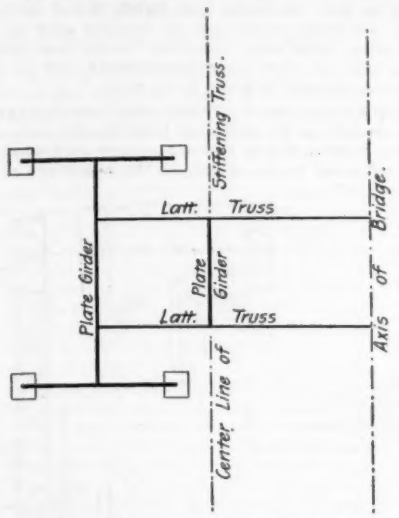



Fig. 4. Diagram Plan Showing Method of Supporting Stiffening Trusses at Tower; New East River Bridge.

not less than 310 ft. long and 28 ft. wide, with a capacity for passing the type of boat recommended by the committee of 1899. This survey is completed, $200,000 having been appropriated for that purpose, and the report of the State Engineer upon it was placed before the Legislature in February, 1901.

In connection with highway improvements, this annual report of State Engineer Bond goes very fully into the tests of road materials, including methods and results. Specifications for cement testing as conducted at the State Testing Laboratory, are given. A large part of the report is devoted to the results of stream gagings in New York state, this department being under the charge of Mr. Robert E. Horton. In a pocket at the back of the book are six maps and profiles giving the results of surveys made for the enlargement of the Erie Canal, as recommended by the Committee on Canals of 1899.

Applications for copies of the report should be addressed to the office of the State Engineer at Albany.

## THE SUSPENDED STRUCTURE FOR THE NEW EAST RIVER BRIDGE.

The last large contract for steelwork on the New East River Bridge at New York city is advertised to be let April 25. This contract includes the suspended structure, comprising the stiffening trusses, transverse bracing and floor framing, which is to be hung from the cables between the main towers, 1,600 ft. apart, c. to c. The various dimensions of the bridge which are interesting in this connection are:

| | Ft. |
|---|---|
| Length of main span, c. to c. of towers | 1,600 |
| Length of entire bridge between terminals | 7,200 |
| Width of bridge main span, over all | 118 |
| Min. height of bridge above M. H. W. of spring tides at pier-head lines | 117 |
| Min. height of bridge above M. H. W. of spring tides for 200 ft. each side of center of main span. | 135 |
| Height of masonry of tower foundation above H.W. | 23 |
| Height of center of cables at top of towers above H. W. | 335 |
| Width of each carriage way | 18 |
| " " 4 trolley car tracks, c. to c., each | 9¾ |
| " " 2 elevated R. R. tracks, c. to c., each | 11 |
| " " 2 footwalks, each | 12 |
| " " 2 bicycle paths, each | 7 |
| " " 2 stiffening trusses, c. to c. | 67 |

As will be recalled from the previous descriptions of this bridge which have appeared in Engineering News, the space between the main tower and the anchorage on each shore is bridged by two spans. The shore span proper on each side extends from the anchorage over and beyond an intermediate tower to form a cantilever arm. The second span or connecting span extends from the end of this cantilever arm to a connection with a cantilever extension of the main stiffening trusses of the suspended structure. Like the shore spans (Eng. News, 1898; I; 114), the suspended span consists of two double intersection trusses with riveted connections. This structure calls for particular description only in respect to the methods by which it is linked to the connecting spans at the ends of the bridge, and by which it is connected with the main tower framing. These details alone have, therefore, been selected for illustration here.

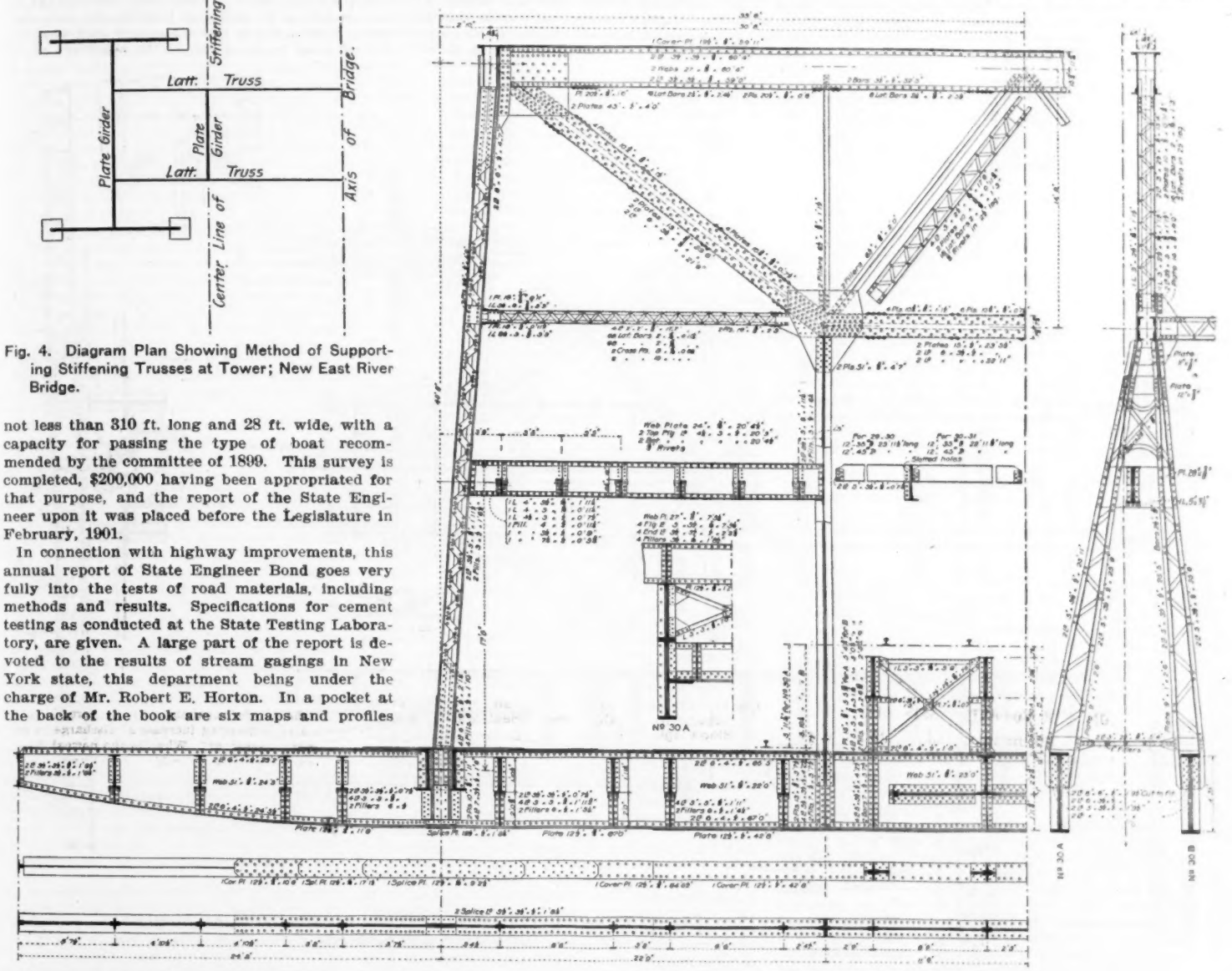



FIG. 2. HALF-TRANSVERSE SECTION OF SUSPENDED STRUCTURE AT TOWER; NEW EAST RIVER BRIDGE.

Fig. 1 shows the end construction of one of the stiffening trusses at the tower. This truss is supported on the tower structure by means which are described later, at panel point No. 30. From this point of support the truss extends shoreward one panel length (to panel point 29), forming a cantilever extension to which the connecting span truss is joined by the pin connection shown. Between panel point 29 and panel point 31 the truss has a special construction, as shown, but beyond panel point 31 the regular double intersection web system begins. These various details are clearly indicated by the drawing. Fig. 2 shows a half transverse section of the suspended structure at panel point 30, Fig. 1. This section shows the stiffening trusses with a batter. This batter exists only for the portion of the truss between panel points 29 and 31, the trusses beyond panel point 31 being vertical.

Turning now to the method of supporting the suspended structure at the tower, the diagram, Fig. 3, and the detail drawings, Fig. 4, may be consulted. The diagram shows in plan the four legs forming one-half of the eight-legged tower. The tower bracing between these four legs carries a plate girder running parallel to the center line of the bridge. This construction is duplicated in the opposite four tower legs, and between the two plate girders are carried two lattice trusses running transversely of the bridge. Between these two trusses at each end is a short plate girder. This plate girder is shown in cross-section at B, Fig. 4. It has a pinhole casting at the center, and carries the stiffening truss by means of the rocker strut shown on Fig. 4. Summarized, the support of the suspended structure at the tower consists of two rocker arms or struts which take up the vertical reactions at the tower and also provide for longitudinal movement of the main and shore spans due to expansion and contraction. To

provide for the swing of the suspended structure in the horizontal plane, and also for a vertical tip, the two parallel floor beams 30 A and 30 B, Fig. 4, are carried by a vertical pivot bearing on a fish-bellied girder supported at each end by cross-girders between the two lattice trusses, Fig. 3. This construction also conveys the stresses of the lateral system to the towers, as clearly indicated by the drawing. The minor structural features are shown by the details of the drawing. The specifications for the material and workmanship are as follows:

MATERIALS.

QUALITY OF STEEL.—All steel shall be made in an open-hearth furnace lined with silica. The stock from which this steel is made shall consist entirely of pig iron, or of washed pig, or of a combination of both. Washed pig shall not be decarbonized below 1½% during washing; and an analysis for carbon, phosphorus and sulphur shall be made from each cast. During the reduction of steel in the open-hearth furnace a complete decarbonization will not be allowed. Acid open-hearth scrap resulting from previous heats for this work may be used in subsequent furnace charges in quantities not exceeding 25%, when permitted by the engineer; but such permission may be withdrawn at any time. No stock used in the open-hearth or in the washing furnace shall contain more than .10% of phosphorus or more than .05% of sulphur. The use of iron ore for the reduction of carbon in the furnace charge will be permitted according to usual and good practice. The recarbonization of steel and addition of manganese shall be performed in a careful manner, giving the most uniform results and to the satisfaction of the engineer. The finished steel shall not contain more than the following proportions of the elements named:

| | |
|---|---|
| Phosphorus | .05% |
| Sulphur | .04 " |
| Manganese | .50 " |
| Silicon | .10 " |
| Copper | .02 " |

The finished steel shall be made into bottom cast ingots of such weight and number in a group as will reduce segregation to a minimum. Specimens cut from the finished material shall have the following physical properties:

| Description of material | Strength in lbs. per sq. in. | Elongation % in 8 ins. | Reduction % of area. |
|---|---|---|---|
| Shapes and universal mill plates.... | 60,000 to 68,000 | 22% | 44% |
| Sheared plates and pins ..... | 60,000 to 68,000 | 20% | 44% |
| Rivet rods..... | 54,000 to 60,000 | 25% | 50% |

Specimens cut from plates and shapes shall bend cold 180° around once the thickness of the specimen; when at or above a red heat, 180° flat; and, when quenched in water at a temperature of 80° F., 180° around three times the thickness of the specimen. Specimens cut from rivet rods shall bend 180° flat when cold, when at or above a red heat, or when quenched from a light yellow heat in water at a temperature of 60° F. The elastic limit of the steel shall not be less than one-half of the ultimate strength. All bending tests shall show no signs of fracture on the outside of the bent portion.

STEEL FOR CASTINGS.—Steel for castings shall be made in an open-hearth furnace lined with silica. At least one-third of all stock used for steel castings shall be pig iron; and, where scrap is used, it shall be of a kind and quality satisfactory to the engineer. During the reduction of the steel in the furnace, it shall not be decarbonized below .10%. The finished steel shall not contain to exceed the following limits of the elements named:

| | |
|---|---|
| Phosphorus | .06% |
| Sulphur | .04 " |
| Manganese | .80 " |
| Silicon | .35 " |

All steel castings shall be carefully and thoroughly annealed. Test pieces taken from coupons on the annealed castings shall show an ultimate strength of not less than 60,000 lbs. per sq. in., an elongation of not less than 20% in 2 ins., and shall bend 90° around three times their thickness without rupture.

WORKMANSHIP.

RIVETED WORK.—All plates and angles to be riveted, which do not exceed ¾-in. in thickness, shall be punched ⅛-in. less in diameter than the rivets to be used; and, after being straightened, shall be assembled and reamed to a diameter not more than 1-16-in. greater than that of the rivet, and all parts of the holes must be cut by the reamer. Plates and angles thicker than ¾-in. shall be assembled and drilled to the proper size to admit the rivets, without punching. In drilling and reaming the parts must be so firmly bolted together that no chips can get between them, and they must not be taken apart after drilling and reaming unless absolutely necessary. All drilled and reamed holes are to be cleared of chips and fins. All sheared edges must be removed by a planer to the depth of at least ⅛-in.

RIVETING.—Wherever practicable, all rivets shall be machine driven, both in the shop and in the field. Wherever hand-riveting is necessary, the entire driving must be done with sledges weighing at least 8 lbs., and the rivets must be held by dollies capable of holding them firmly against such driving. All rivets must thoroughly fill the holes, have full hemispherical heads concentric with their bodies, and grip the work tightly. All work must be kept thoroughly and tightly bolted while the rivets are being driven, and all members must be true and out of wind when completed. Great care must be taken that all rivets are properly heated, and no overheated rivets shall be driven in the work.

REMOVAL OF MILL SCALE.—After punching and before assembling, all steel shall have the mill scale thoroughly removed and be carefully cleaned from all grease, dirt and other foreign matter to the satisfaction of the engineer. Contact surfaces shall each receive one coat of approved protective material before assembling. After riveting and before exposure to oxidation the members shall be cleaned again, if necessary, and shall receive a coat of approved paint; but no paint shall be applied to a damp surface or at a temperature below 40° F. After the first coat is dry a second coat of paint shall be applied under the same limitations as the first and allowed to dry before the shipment of the material.

ABUTTING ENDS, SPLICES AND GUSSETS.—All abutting ends and edges shall be milled or planed, so that the parts shall fit neatly and tightly together. All joints must be assembled after milling, and the holes in the splice plates and gussets must then be reamed or drilled, so that they will agree perfectly.

PINS.—All pins must be turned smooth and truly cylindrical to the diameters called for by the plans. They must be of the correct length to give full bearing. All pins more than 6 ins. in diameter shall be hammered. All pins having a greater diameter than 6 ins. must have holes 1½ ins. in diameter, concentric with the cylindrical surface of the pin, bored through them from end to end.

PAINTING.—After the erection is completed, the metal will receive two thorough coats of a paint approved by the

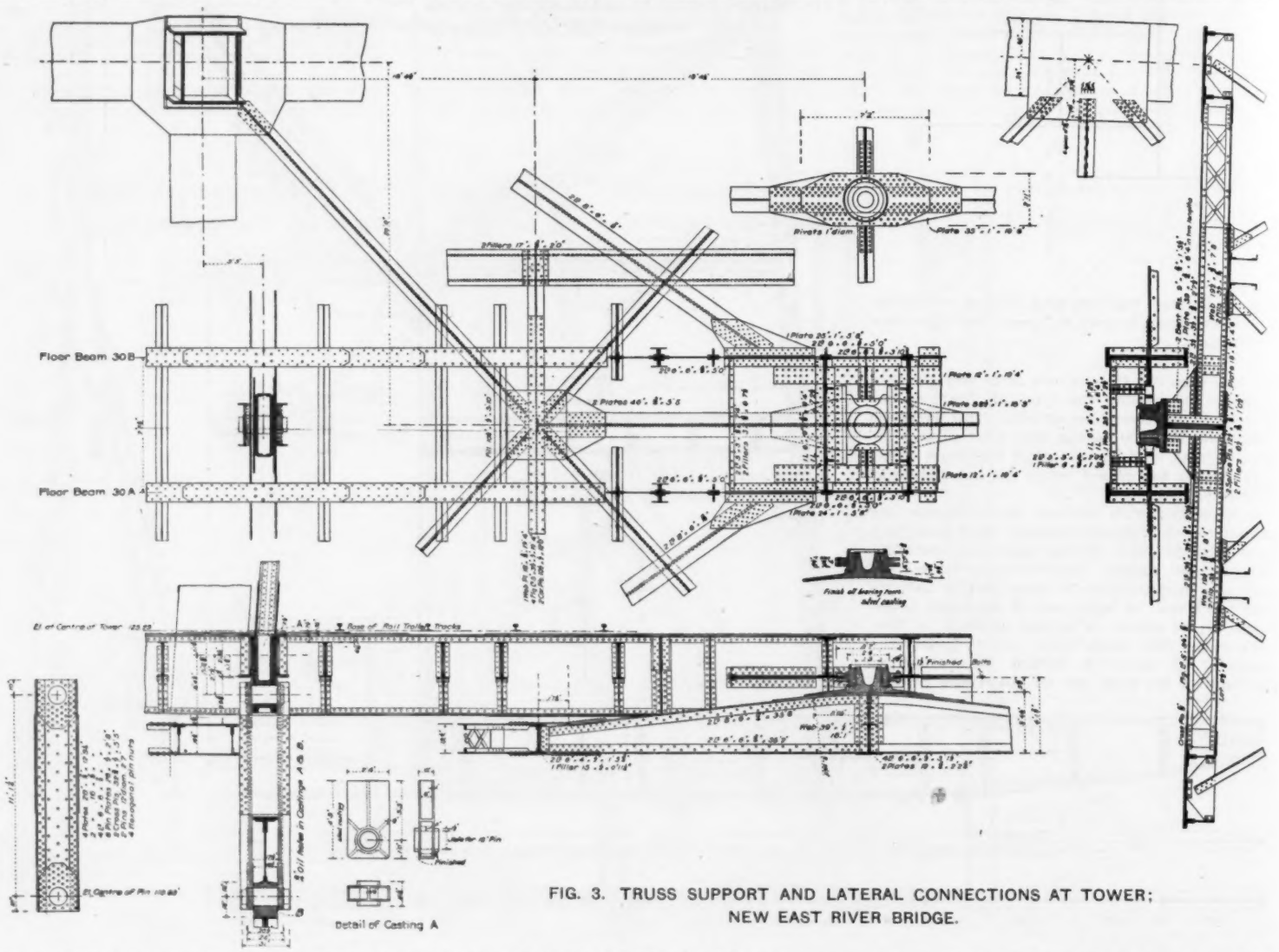



FIG. 3. TRUSS SUPPORT AND LATERAL CONNECTIONS AT TOWER; NEW EAST RIVER BRIDGE.

engineer; and all friction surfaces and the surfaces with which they come into contact, will receive a coating of vacuum flushing oil mixed with graphite.

Mr. L. L. Buck, M. Am. Soc. C. E., is Chief Engineer of the New East River Bridge, and Mr. O. F. Nichols, M. Am. Soc. C. E., is Principal Assistant Engineer. We are indebted to these gentlemen for the information from which this description has been prepared.

## CONSTRUCTION AND CARE OF EARTH ROADS IN ILLINOIS.*

By Ira O. Baker, M. Am. Soc. C. E.†

### I. CONSTRUCTION.

Drainage is the most important matter to be considered in the construction of earth roads. No road, whether earth or stone, can long remain good without drainage. Drainage alone will often change a bad earth road to a good one, and the best road may be destroyed by the absence of proper drainage. Water is the only agent that destroys earth roads. No road, however well made otherwise, can endure if the water collects or remain on it. A perfectly drained road will have three systems of drainage, each of which must receive special attention if the best results are to be obtained. This is true whether the trackway be iron, broken stone, gravel or earth, and it is emphatically true of earth. These three systems are, underdrainage, side ditches and surface drainage.

UNDERDRAINAGE.—Many, if not most, country highways could be considerably improved by thorough subdrainage. Most people appear to think that the sole object of tile drainage is to remove the surface water, but this is only a small part of the object of the underdrainage of roads. The most important object of underdrainage is to lower the water level in the soil. The action of the sun and the breeze will finally dry the surface of the road, but if the foundation is soft and spongy, the wheels wear ruts and horses' feet make depressions between the ruts. The first shower fills these depressions with water, and the road is soon a mass of mud. A good road cannot be maintained without a good foundation, and an undrained soil is a poor foundation.

A second object of underdrainage is to dry the ground quickly after a freeze. When the frost comes out of the ground in the spring, it thaws quite as much from the bottom as from the top. If the land is underdrained, the water when released by thawing from below will be immediately carried away. This is particularly important in road drainage, since the foundation of the road will then remain solid and the road itself will not be cut up like untiled roads.

A third, and sometimes a very important, object of subdrainage is to remove what may be called the underflow. In some places where the ground is comparatively dry when it freezes in the fall, it will be very wet in the spring when the frost comes out—surprisingly so considering the dryness before freezing. The explanation is that after the ground freezes, water rises slowly in the soil by hydrostatic pressure of the water in higher places; and if it is not drawn off by underdrainage it saturates the subsoil and rises as the frost goes out, so that ground which was comparatively dry when it froze is practically saturated when it thaws.

The underdrainage of a road not only removes the water, but prevents, or greatly reduces, the destructive effect of frost. Water expands on freezing and loosens the soil; when thawing takes place, the ground is left spongy and wet, and the roads "break up." If the roads are kept dry they will not break up. Underdrainage helps to keep them dry.

It is the universal observation that roads in low places which are tiled dry out sooner than the untiled roads on the high land. The tiled roads never get so bad as those not tiled. There is no way in which road taxes can be spent to better advantage than in tiling the roads. The cost of tile drainage is not great, say, about 50 cents per rod or $160 per mile; the improvement is permanent with no expense for maintenance; and the benefit is immediate and certain. Farther, tile drainage is the very best preparation for a gravel or a stone road. Gravel or broken stone placed upon an undrained foundation is almost sure to sink gadually, whatever its thickness; whereas a thinner layer upon an underdrained roadbed will give much better service. "Roads tiled without gravel are better than roads graveled without tile."

The road should be underdrained so as to keep the water level well below the road surface. In most localities this can be accomplished reasonably well by laying a line of farm tile 3 or 3½ ft. below the road surface along one side of the roadway. It is sometimes claimed that there should be a tile on each side of the road. Some tests recently made by the Illinois Experiment station seem to indicate that one line will give fairly good drainage under the most adverse conditions. The experiment consisted in the drainage of a piece of land selected as the worst that could be found in a part of the state notorious as having a large area of hand-pan which it was generally considered could not be underdrained "because the soil held water like a jug." Lines of tile were placed 2½ ft. deep and 50 ft. apart. The water level at a point midway between the lines of tiles was lowered 18 ins., when at the same time the water level in the undrained portion of the field was only 6 ins. below the surface. In this case the surface of the ground water had a slope of 1 ft. in 25 ft., but in a more porous soil the slope would be much less. Therefore a single line of tile 3 or 3½ ft. deep, if of adequate size, will give nearly perfect drainage; and a second line will not materially improve it.

Some writers on good roads advocate the use of a line of tile under the middle of the traveled portion, and some advocate a line on each side of the wheelway. The object sought by these tile is rapid drainage, and, therefore, it is urged that they should be laid near the surface. It is doubtful whether any water will reach the tile, since the road surface when wet is puddled by the traffic, which prevents the water percolating through the soil; and it is certain that in clay or loam the drainage thus obtained is of no practical value.

While a line of tile on one side of the road is usually sufficient, there is often a great difference as to the side on which it should be laid. If one side of the road is higher than the other, the tile should be on the high side to intercept the ground water that is flowing down the slope under the surface. Sometimes a piece of road is wet because of a spring in the vicinity; or perhaps the road is mudddy because of a stratum which brings the water to the road from higher ground; in either case, tap the source of supply with a line of tile instead of trying to improve the road by piling up earth.

The tile should be laid in the bottom of the side ditch, below the frost line. Of course, the tile should have a uniform grade, and a sufficient fall and an adequate outlet. The size of the tile required will depend upon the length of the line and the grade of the ditch, but local experience in farm drainage is likely to be a better guide than any general statement that can be made here.

It is hoped that in this day and age of the world no Illinoisan will attempt to follow several writers on good roads in the use of such substitutes for tile as the following, which are illustrated in two official publications open before the writer: "Subdrains made with field stones," "subdrains made of bundles of brush," "subdrains made of logs and faggots," "subdrains made of brick."

SIDE DITCHES.—The side ditches are to receive the water from the surface of the traveled way, and should carry it rapidly and entirely away from the roadside. They are useful, also, to intercept and carry off the water that would otherwise flow from the side hills upon the road. Ordinarily they need not be deep, and if possible should have a broad, flaring side toward the traveled way, to prevent accident if a vehicle should be crowded to the extreme side of the roadway. The outside bank should be flat enough to prevent caving. The proper form of ditch is easily made by the usual road machine or road grader. The side ditch should have a free outlet into some stream, so as to carry the water entirely away from the road. No good road can be obtained with side ditches that hold the water until it evaporates. A road between long artificial ponds is always inferior and is often impassable. It is cheaper and better to make a lower embankment, and to drain thoroughly the holes at the side of the roads. Often the public funds can be more wisely used in making ditches in adjoining private lands than in making ponds at the roadside in an attempt to improve the road by raising the surface.

When the road is in excavation, great care should be taken that a side ditch is provided on each side to carry away the water so that it shall not run down the middle of the road—as is frequently the case. Every road should have side ditches, even one that runs straight down the side of a hill. The steepest road needs the side ditch most, but often has none. Frequently the water runs down the middle of the road on a side hill and wears it into gullies, which are a discomfort and perhaps dangerous, in both wet weather and dry. The water must not be suffered to run in the road, but must be made to run off the road.

As a rule the side ditches cannot have too much fall, but sometimes a ditch straight down a hill will have so much fall as to wash rapidly, in which case it is an advantage to put in an obstruction of stone or brush. In extreme cases the bottom of the ditch is paved with stones.

SURFACE DRAINAGE.—The surface drainage of the traveled portion of a road is fully as important as its underdrainage, and is provided for by making the surface crowning. Drainage of the surface is a matter chiefly affecting the maintenance of the roads.

The slope from the center to the side ditch should be enough to carry the water freely and quickly to the side ditch. A crown at the center of 12 ins. in 25 or 30 ft. is sufficient. The better the surface is cared for, i. e., the smoother the surface is kept, the less the crown required. If there is not enough crown, the water cannot easily reach the side ditches, and hence the road soon becomes water soaked.

The crown can be too great. If the side slopes are so steep that traffic keeps continually in the middle of the road, it will be worn hollow and retain the water instead of shedding it promptly to the side ditches. Again, if the earth is piled too high in the middle, the side slopes will be washed into the side ditches, which not only damages the road, but fills up the side ditches.

The crown should be greater on steep grade than on the more level portions, since on the grade the line of steepest descent is not perpendicular to the length of the road and consequently the water in getting from the center of the road to the side ditches travels obliquely down the road.

There has been considerable discussion as to the exact form to be given to the surface of the roadway. Some claim that it should be the arc of a circle, and others that it should consist of two planes meeting at the center and having their junction rounded off with a short curve. The latter form is probably the better, but great refinement in this matter is neither possible nor important.

The proper crown can be easily and cheaply obtained by the use of the road machine or grader, of which there is a variety of excellent forms on the market. After the roadbed has been rounded with the grader, it should be rolled with as heavy a roller as is available. Rolling compacts the earth and prevents it from being cut up by subsequent traffic, and also prevents the earth from washing into the side ditches. The road should not be rounded up late in the summer or in the fall, for then the earth thrown up in the center will not unite with the foundation—even after being rolled, unless the fall is an unusually wet one.

A common defect of earth roads is the lack of any attempt at crown. Seldom is a mile seen of which all is properly crowned. Often a cheap wood-box culvert is only half or third as long as the traveled way is wide, and hence the traffic is concentrated upon a small part of the width of the road—and that, too, in a low place where the roadbed is wettest.

### II. MAINTENANCE.

Maintenance is important with any road, as no style of construction is sufficiently permanent to admit of the road's being left to take care of itself. Whether built of earth or stone, it will eventually wear into ruts and holes, the time depending upon the quality of the material, the form of construction, and the amount of the traffic. When ruts or holes have been formed, the deterioration of the road will proceed rapidly unless repairs are promptly made.

The chief object in the maintenance of an earth road is to get rid of the water as quickly and as fully as possible. In maintenance, as in construction, water is the great enemy of good roads. The secret of success in maintenance is to keep the surface smooth and the side ditches open.

CARE OF THE SURFACE.—If the surface of the roadway is properly formed and kept smooth, the water will be shed into the side ditches and do comparatively little harm; but if it remains upon the surface, it will be absorbed and convert the road into mud. If all ruts, depressions, and mud holes are not filled as soon as they appear, they will retain the water upon the surface, to be removed only by gradually soaking into the roadbed and by slowly evaporating; and each passing wheel or hoof will help to destroy the road.

There are several machines or devices which are very effective in filling the ruts and depressions, and in keeping the surface smooth. Different tools are best under different conditions. These tools and the mehtod of using them will be considered briefly.

In the winter there frequently come times when the road is full of holes and ruts, while the surface soil is dry and mellow. This condition occurs most frequently when the ground below the surface is frozen. If at this time a harrow is run over the road, it will fill up the ruts and holes and leave the surface smooth. This improves the road for present travel, and gives a smooth surface which will greatly decrease the deterioration of the road by subsequent rains. Often there is only a few hours in the middle of the day when the frost is out of the ground sufficiently to permit this work to be done, and, therefore, it is best to have each farmer harrow the road adjoining his own land. The ordinary adjustable farm harrow should be used, and the teeth should be set to slope well back. The labor required is not great, since a 12-ft. harrow can be used, and then a single round is sufficient. The work comes at a time of the year when the farmer's time is usually not very valuable, and hence the expense is small. The writer has seen frequent examples of this method of treating the roads, which have proved very beneficial both in securing good roads and preserving them.

In the early spring just after the frost goes out of the ground, earth roads are usually full of deep ruts. At this time the roads can be greatly improved by running over them that tool called indifferently "road machine," "road grader," "road plane," or "road leveler." The object is simply to cut off the ridges and fill up the ruts, and thus "break the way" for travel. It is well to break the road early in the season, both to accommodate the present travel and to hasten the coming of a better condition of the road. It is much more economical to make the road smooth with the machine than to wear it down by travel.

There are many road machines on the market, all of

*Extract from a bulletin issued by the Illinois Agricultural Experiment Station. For copies of the Bulletin address E. Davenport, Director, Urbana, Ill.

†Professor of Civil Engineering, University of Illinois, Champaign, Ill.

which are most excellent for certain kinds of work to be referred to later, but most of which are too heavy and too elaborate to fit the conditions just described. The machines are mounted upon four wheels, and of themselves are a considerable load over roads which are only a succession of ridges, ruts and mud holes; and are heavier and more cumbersome than is necessary for the work now under consideration. The writer has seen a heavy stick of timber shod with a steel plate and drawn by two horses, used for this purpose with great success. He has also seen a railroad rail so used. The rail is usually 14 or 16 ft. long, and is drawn by four horses. When the ground is mellow and loose after freezing and thawing, the rail will smooth the road down nicely, and do it more rapidly than the road machine, since it cuts a wider swath. One round trip is sufficient for any road. The time when the work is most advantageously done is comparatively limited, and, therefore, one rail should not be expected to cover too much road. If the roads are treated with the light scraper or railroad rail, they will not get so rough and hence will not require so much work later with the heavy road machine.

In the late spring after the ground has settled, the roads should be prepared for summer travel by being shaped up with the "road machine" or "road grader." When this work is to be done, the ground is comparatively dry, and consequently the heavier road scraper is required and can be handled on the roads. It is somewhat unfortunate that this tool is ordinarily called a road grader, since the name has possibly led to a misconception as to an important use of the machine. As an instrument of road construction, this machine is used to give a crown to the road; but as an instrument of maintenance, it should be used only to smooth the surface and restore the original crown. Apparently some operators assume that the machine is not to be used except to increase the crown of the road. Employed in this way the crown is made too great, and a big ridge of loose earth is left in the middle of the road which only slowly consolidates and which is likely to be washed into the side ditches to make trouble there. Since the introduction of the road machine there has developed a strong tendency to increase the crown of the road unduly. Doubtless the object is to secure better drainage of the roadbed, but piling up the earth is an inadequate substitute for tile drainage. Side slopes steeper than just enough to turn the water into the side ditches are a detriment. Other things being equal, the best road to travel on or to haul a load over is a perfectly flat one.

In smoothing the road, the road machine should be run over the ground lightly so as to smooth down the ridges and fill up the ruts. Only enough earth should be moved toward the center of the roadway to replace that washed down by the rains. The blade should stand nearly square across the road, and considerable earth should be shoved along in front of the blade so as to have enough loose earth to fill any depressions. The surplus earth should be evenly distributed along on the surface. This work should be done early—before the ground becomes hard and difficult to work, and before traffic has been compelled partially to do the work of the road leveler, and while the surface is in condition to unite with the loose earth left by the machine. Unfortunately this work is often postponed until the ground is so hard that it is impossible to do a thoroughly good job. If the ground is a little too wet for agricultural tillage it is all the better for roadmaking, since it will pack better than though it were drier. During the summer, if the road becomes very badly rutted, the road machine should be run lightly over it.

In the summer, when the roads get roughed up, they can be materially improved at small expense by running over them with a harrow having the teeth down quite flat. If the roads are a little muddy, this treatment will make them dry faster and also make them much more pleasant to use after they have dried.

Finally, during the fall the roads should be repaired with special reference to getting them into good shape for the winter. Any saucer-like depressions or ruts should be filled with earth like that of the roadbed. The material should be solidly tamped into place. Holes and ruts should never be filled with stone, bricks, or coarse gravel. The hard material will not wear uniform with the rest of the road, but produce bumps and ridges, and usually result in making two holes, each larger than the original one. It is a bad practice to cut a gutter from a hole to drain it to the side of the road. Filling it is the proper course, whether the hole is dry or contains mud.

SAND ROADS.—Roads on pure or nearly pure sand require very different treatment than roads on clay and loam. Dampness improves the sand road, while it damages a clay or loam road. The preceding rules for the drainage of loam or clay roads must be reversed for sand roads. Wet sand makes a better road than dry sand, and, therefore, draining a sand road is useless and possibly a damage. Sand roads are usually nearly level and need little, if any, grading. They should not be crowned, since they do not need surface drainage. The traveled portion should be simply leveled off.

The only thorough and permanent improvement possible for a sand road is to add a layer of tough clay and incorporate it with the sand. This is expensive at best, and it is difficult to get the sand and clay thoroughly incorporated in the right porportions.

## FINAL REPORT ON THE DYNAMITING OF THE BRUNSWICK OUTER BAR, GA.

The River and Harbor Acts of 1894 and 1896 made a conditional contract with C. P. Goodyear for deepening the outer bar of Brunswick, Ga., providing for channels 24 ft. deep and 200 ft. wide and 25 ft. deep and 100 ft. If these depths were obtained before June 3, 1900, Mr. Goodyear was to obtain the sums named in the Acts. The River and Harbor Act of 1899 provided that after June 3, 1900, a survey was to be made and a plan reported upon for obtaining a depth of 26 ft. at mean low tide, with a width of 200 ft. The duty of making this survey was assigned to Capt. C. E. Gillette, Corps of Engineers, U. S. A., and his report was submitted to the Chief of Engineers, under date of Dec. 27, 1900.

Prior to 1879, the channel depth across this bar was about 17 ft. at mean low water; between 1879 and 1889 this channel became practically obliterated, and the best available depth in 1889 was 13 ft. at mean low water. The navigable depth at the date of the present report was 18 ft.

The idea of using dynamite for opening a channel through an ocean bar originated, about 1891, with Mr. C. P. Goodyear and his associates, of Brunswick, Ga. These gentlemen commenced using dynamite upon this bar in 1891; aided this work afterwards with harrows, etc., and finally resorted to ordinary hydraulic dredging. A good channel now exists, and the question is as to how much of that channel has been caused by dynamite, how much by nature, and how much by ordinary dredging; with a view to determining the value of dynamite for this purpose, considering the cost of the work to the government and to the contractor.

Mr. Goodyear claims that the bottom of the channel, at the beginning of the work, had a hard top crust, about 1 ft. deep, made of sand, shells and gravel, and below this was a layer of blue clay about 4 ft. thick. On the bar the hard material was 3 to 4 ft. thick; and the general contention of Mr. Goodyear and his engineers was that this material would not erode under the action of water. But Lieutenant Thos. H. Rees, Corps of Engineers, U. S. A., reports in the same year, 1891, that while this bottom was very firm and compact while the ebb current continued; as soon as the flood current was established the bottom became soft and loosened, or "alive." Lieutenant Reese explains this by the action of the difference of hydraulic levels in the tidal wave approaching the shore; during flood the greater elevation exists out at sea, and the water flowing in finds its way through the saturated sand and mud and lifts these and stirs up the bottom.

Mr. Goodyear, in advocating the use of dynamite, contended that the explosive has a wide-spreading effect "due to vibration" through the earth; the explosion of a 200-lb. charge being distinctly felt 4½ miles away. He said that this vibration over wide areas changed the nature of the bottom, from a non-erosive to erosive material, which could be taken up by the currents, put in suspension and carried away. He illustrated this theory by observations made at Brunswick bar and at Aransas Pass, where dynamite was used; and claims that at the latter place, where a ¾-in. iron bar could not be forced into the bottom under ordinary conditions, an ordinary oar could be pushed down 2 or 3 ft. while dynamiting was going on, 1,000 ft. away.

Captain Gillette characterizes these statements as "quite remarkable," and says that they apparently furnish strong evidence that dynamite can produce considerable effect at a considerable distance. But Captain Gillette notes that these observers may not have been aware of the fact that sand on ocean bars is often "alive" at flood and hard at ebb tide. Other witnesses give a somewhat different version of the "iron-bar story," in stating that while a pole could be pushed down 2 or 3 ft. into the sand in the immediate vicinity of the explosion, if left there a short time the sand would settle so firmly around it that it would be very hard to pull up. To throw some light on these points, Capt. Gillette made a small experiment on Tybee beach. He had ordinary eggs buried from 1 to 3 ins. deep in the sand and just awash at low tide; and at high tide he exploded a charge of 42 lbs. of 60% Ætna brand dynamite. This explosion threw up a column of water and sand 80 ft. high—and fish jumped from the water 600 ft. away. The nearest egg, 110 ft. away, was found broken at low tide; but two, 115 ft. away, were found intact; and those at greater distance from the charge, 160 ft. to 315 ft. away, were all unbroken. The experiment would indicate that the explosion of 100 lbs. of dynamite would have a very mild effect on the bar at quite short distances; especially upon tough, non-erosive blue clay, which it was claimed existed all over the bar.

By comparing the various surveys on the bar from 1891 to 1899 inclusive, it is seen that lively changes were going on in the bar between January and April, 1891, before any dynamiting was done, to "render it erosive." Within that period a long tongue of deep water, 18 ft., shot out seaward from the deep pocket inside; this was quite near the present Goodyear channel, and showed a decided tendency to deepen on that line. "months before "it developed that natural laws were greatly aiding in the work;" months before "soundings showed us that at a point of less depth by 3 ft. than where we were working, nature, aided by these vibrations, had broken through." It would appear that nature had nearly broken through without the vibrations.

The maps and tables given in the report show that from January, 1891, to December, 1895, the last survey before dredging was resorted to, the increase in the controlling depth of "best water" was from 13.3 ft. to 15 ft., a total gain of 1.7 ft. as a showing for four years' hard work and the explosion of about 100,000 lbs. of dynamite. Dredging without bins commenced in July, 1896; and in February, 1897, the government survey showed a gain of 1.6 ft.; or, practically as much as had been gained in the previous four years of dynamiting. Ordinary dredging was later resorted to, with an additional depth secured of 1.9 ft., or a total increase in navigable depth over the

Fig. 2. Installation at Indian Head, Md.

bar of 5.2 ft. Of this 5.2 ft., 1.7 ft. occurred during the four years of dynamiting, and 3.5 ft. during the four years of dredging since 1895.

As to the amount of material actually removed from the Goodyear channel and vicinity, the official surveys of 1891, 1897, 1898 and 1899, show that up to 1897 the total result in the vicinity of the Goodyear channel was a fill instead of a scour. This was the period covering the use of dynamite, harrows and dredge without bins. From 1897 to 1899, the period in which ordinary dredging was used, the scour was somewhat greater; but only aggregated in volume about two months' work of an ordinary seagoing dredge. The re-

sults for the total period, 1891-99, show a maximum of 218,260 cu. yds., considering a channel 800 ft. wide, or 400 ft. on each side of the axis of the present channel. For this work Mr. Goodyear has been paid $220,000; and the numerous surveys to determine the results of the work have cost $26,989.83. With this total expenditure of $246,989.83, the government has paid for the work at the rate of $1.13 per cubic yard, or more than seven times the cost of the same results secured by ordinary dredging.

This rate assumes that the removal over this wide area was all useful, and that it was all done by Mr. Goodyear. But Captain Gillette points out that since 1857 the north shoal has been steadily moving southward towards the present channel; and cross sections taken at different times show that the free waterway to the ocean for the flow of the tides has become very much obstructed. As the tidal volume crossing the bar has not been lessened, its velocity and scouring action must, therefore, be greatly increased. Under such conditions nature would strive to make a new channel to permit the tide to flow as freely as before.

Captain Gillette concludes that to secure 18½ ft. depth on the line of the present channel, taking the bottom as found before Mr. Goodyear commenced work, would have required the removal of 103,287 cu. yds. of material; or say 125,000 cu. yds. to cover any extra depths found in the present channel. At 15 cts. per cu. yd., the entire cost would have been $18,750, or about two-thirds of the amount of money the government has expended in making the surveys to find out what Mr. Goodyear had accomplished.

## TWO SURFACE-CONTACT ELECTRIC RAILWAY SYSTEMS.

The street-railway engineer has long dreamed of the happy time to come when he should be able to dispense with the unsatisfactory trolley and the unsightly poles and wires, and should collect the current required to propel his car by means of a simple shoe sliding on a bare third-rail, which should neither be enclosed in an expensive conduit nor be dangerous to the unwary pedestrian. The realization of this dream has been the object sought by countless inventors, whose efforts have seemed to serve only to swell the patent records and fill the pockets of the patent attorneys.

The successful "safety third-rail," or "surface contact," system has not yet been placed in extensive commercial operation, at least not in America. Of the many devices proposed only a few have ever reached the stage of actual test. They have been discarded for various reasons, usually because they were either too complicated or too delicate in their construction and operation to meet the severe conditions of every-day use on a busy street railway, or because they demanded too much machinery on board the car, or too great cost in their installation. However, in spite of all past failures, we may still hope for a workable surface-contact system, since the advantages of such a system are both numerous and manifest, and the difficulties are probably surmountable, as they have been found chiefly in details of construction.

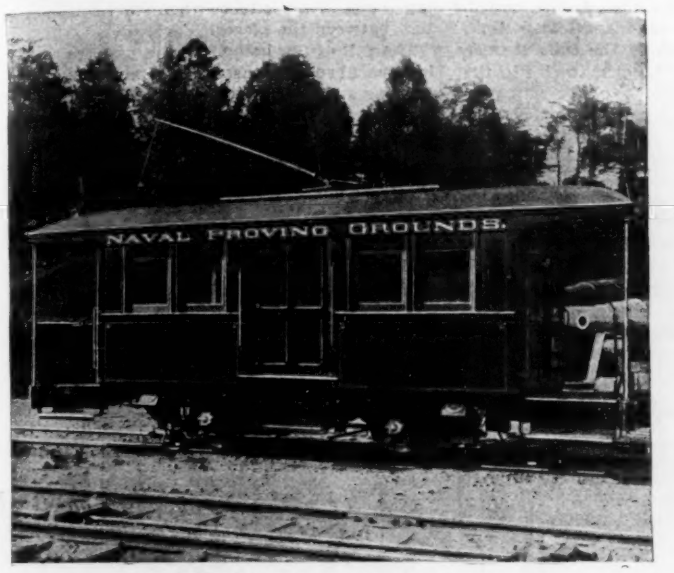



FIG. 1 70-HP. COMBINATION PASSENGER AND FREIGHT CAR.

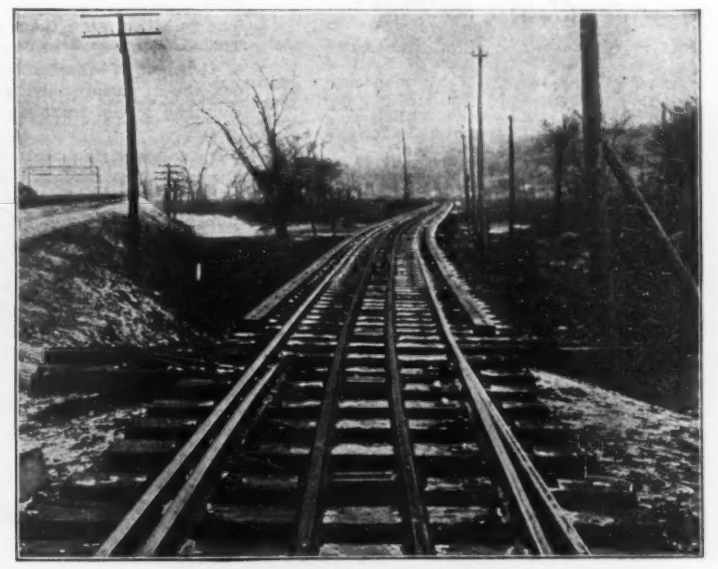


FIG. 3. SECTIONAL-RAIL INSTALLATION.

### THE WESTINGHOUSE SYSTEM.

The Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., has recently issued a pamphlet describing a system of electric traction which has been elaborated by their engineers during the past five years. They have installed this system in and about their shops at East Pittsburg, Pa., where they also have a mile or so of experimental track. In addition to this, a half-mile of track at the Naval Proving Grounds, at Indian Head, Md., has been equipped with the system. This is where the track crosses the proving ground, and where overhead wires would be objectionable, as they might be hit by the projectiles. The remainder of the line at Indian Head uses the overhead trolley, and the cars are, therefore, fitted for both systems. There are two 100-HP. Baldwin-Westinghouse freight locomotives and a 70-HP. combined passenger and freight car, shown in Fig. 1.

The Westinghouse system is of the "electro-magnetic" type; that is, current furnished by the car operates a switch which temporarily connects the section of the third-rail over which the car is standing to the feeder. The term "third-rail" used above, must be understood to include also the "button system," in which the third-rail is replaced by a row of metallic contact buttons, and the cars, instead of being provided with a shoe, are furnished with a slide-rail or bar long enough to reach from one button to another. Both systems are illustrated in the accompanying photographs. The Westinghouse Company prefers to use a double third-rail or row of buttons. Fig. 4 shows the rail connections. If a low voltage is applied between 1 and the service rail, a current flows along the fine wire M, energizing the solenoid S, and drawing up the plunger P. This closes the switch J J, and makes the button 2 "live." This button, or rail, corresponds to the ordinary trolley wire, and current is drawn from it as long as the car is over that section. As the wire N makes several turns around the solenoid, the service current acts to keep the switch closed and the circuit M, being no longer needed, is broken by a small auxiliary switch operated by the circuit N. The car connections are shown in Fig. 5. At the start the switch A is closed, completing the circuit through the storage battery, the "pick-up bar" resting on 1, the circuit M and the rail. A is then opened and switch C is closed. The storage battery is thus cut out and current is furnished to the pick-up bar from the line, the voltage being properly reduced by the resistance L. The operation just described needs to be gone through with only at the start, or when the current has been dropped from some cause or other, and it is all accomplished by merely turning a handle.

The electro-magnetic switch without its cover is shown in Fig. 6. It may be placed anywhere near the track, as shown in Fig. 7, or the buttons may be mounted on the switch-box, Figs. 8 and 9. The switch and solenoid are entirely protected from moisture by the oil-seal at O, Fig. 9.

When the buttons are placed in a single row, or when a single rail is used, it is necessary that the "pick-up" current should be of the same voltage as the main current. This is because the winding M would then be liable to have the full line voltage thrown upon it, and so must be designed for that voltage. For this case the car wiring, shown in Fig. 10, is used instead of that shown in Fig. 5. Only a small number of storage cells are carried, as before, but current is furnished at the line voltage by the motor-generator F. This device is in use only when picking up the current.

The button system is intended for use about shops and switch-yards, and for street railways. It is well adapted for such places, as none of the conductors are "live," except those immediately under the car. To secure the same advantage with the third-rail would necessitate very short rails. The buttons need be raised only about ¾-in. above the pavement, and would interfere in no way with street traffic. The manufacturers estimate that this system can be installed for about half the cost of an open conduit. Remembering the great difficulties experienced with the latter in times of heavy rains, it would seem that the system under discussion would be quite as reliable.

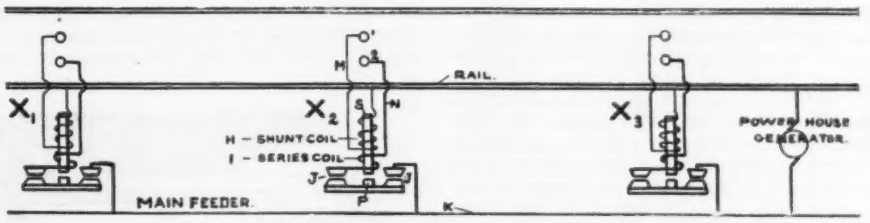



FIG. 4. DIAGRAM OF SWITCH CONNECTIONS.

For suburban lines it is recommended that the third-rail be connected in sections about 500 ft. long, except near crossings where persons are liable to come in contact with the rail. By simply

cutting off the current the motorman can render the rail "dead" at any moment, if necessary. The rail section shown in Fig. 11 is considered most suitable for the conducting rail. The same figure shows a method of splicing and bonding the rail. In the "plastic" bond shown some sort of amalgam

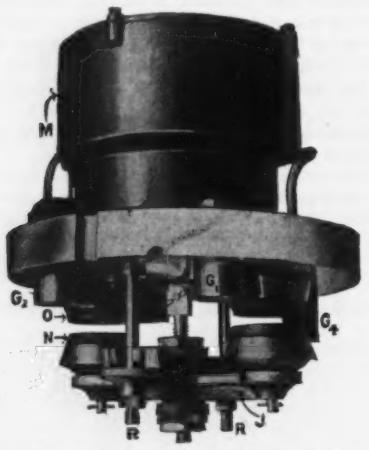



Fig. 6. Electro-Magnetic Switch.

is used to make connection between the rail and the copper bond-strips. This amalgam is protected from the air by a cork casing.

### THE DIATTO SYSTEM.

In France the Diatto surface-contact system has met with considerable favor, and there are from 70 to 80 miles of road equipped with it, in operation or being built. It differs from most other systems in that the switches are not operated by an auxiliary electric circuit, but are caused to act by the attraction exerted upon a movable part of the switch by a strong electro-magnet carried by the car.

The switches are contained in boxes placed at short intervals along the middle of the car track. These boxes have metallic covers which rise slightly above the surrounding pavement, and constitute the contact buttons from which the current is taken off. Fig. 12 shows the details of construction of the switch-box and the contained switch. The block S is of asphalt. It is hollow, the opening being continued downward into the ground by the vitrified pipe P. The opening is closed by the removable cover A, which is of non-magnetic material, except the core C, which is of iron. The cover rests upon and is secured by three bolts E, to the bronze crown B, set into the asphalt.

A piece of cast iron M, of high magnetic permeability, is imbedded in the asphalt. It supports a cross-piece L, also of cast iron, provided with a socket at the middle holding the ebonite mercury cup J. The extremities of the piece M are turned upwards towards the surface of the asphalt.

The lower end of the mercury cup is closed by the copper screw plug N, which terminates in a copper wire dipping into another mercury cup O, the latter cup being formed of metal and supported by the feeder wire Q. An iron bolt K floats in the mercury in the first cup. The quantity of the mercury and the shape of the bolt are such that when the latter is in its lowest position its weight is balanced by the pressure of the liquid and a very small force suffices to raise it. The top of the bolt is provided with a carbon head H. A plug D screwed into the core C carries on its lower side the cup-shaped block of carbon G. The brass bell

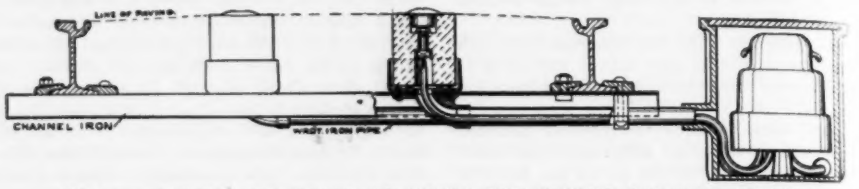



FIG. 7. SECTION OF TRACK EQUIPPED FOR STREET RAILWAY SERVICE.

I is secured to the core C by the plug D, and it in turn supports by three bolts the ebonite cup J. The joint between them is made perfectly tight. The ebonite cup is prolonged by the tube R, also of ebonite. If water should happen to rise in the box the air imprisoned within the tube will prevent the water from reaching the mercury contact.

The magnetizing bars carried by the car are of a special type, designed particularly for this service. There are three long shoes or bars of iron connected by iron yokes at frequent intervals. The latter are provided with two sets of windings, through one or the other of which an electric current is always passing in such a direction as to make the middle bar a North pole and the side bars South poles. In normal operation the current propelling the car passes through one set of windings and excites the magnet. But for use when first starting or when the main current has been cut off, a storage battery placed under the seats of the car furnishes current to the second set of windings. The total space occupied by this battery is 31.5 × 9.8 × 15 ins., and it supplies a current of 18 amperes at 10 volts. It is to be noted that when the car is receiving current from the contact button, the magnet is energized by the motor current, and that the pressure on the carbon contacts of the switch will be the stronger the stronger the current.

The carbon contacts are of very pure and hard carbon, and show no tendency to glue together. Moreover, no arcing can take place within the box, since the circuit is broken at the contact button on the street. The rear end of the middle contact bar is raised slightly, so that electrical contact with the button is broken before the magnetic pull ceases to act upon the bolt K; therefore the latter does not fall until after the current has ceased flowing. Since the bolt K never actually touches the core C, there is no danger of its being retained by remanent magnetism, the latter having very little effect when there is not contact between the pieces.

The fall of the bolt after the passage of the car is thus absolutely assured. But to meet all objections a further precaution has been taken. The copper wire Y, which dips in the cup O, is provided with a fuse. A trailer carried by the car touches the buttons and the rails, and if a switch has failed to drop after the passage of the collecting shoe, it will be short-circuited, and the fuse will be blown. There is thus no possibility of live buttons being left behind the car.

We may now recapitulate and explain the action of the different parts. At the start the current from the battery circulating in the windings of the pick-up magnet induces a magnetic flux through the latter. The magnetic circuit is completed from the North pole N, through C, K, L and M to the South pole S. All open parts of the circuit in the iron having a tendency to close, the bolt K is drawn upwards towards C until the carbons meet. The current from the battery is never cut off except during stops in the daytime. It is necessary to keep it on continuously during the night, as otherwise the lights in the car would go out whenever the motor current was cut off. The course of the latter current is from the top to the feeder Q through the cup O, the wire Y and the plug N to the mercury and the bolt K; from there through the carbon contacts, the plug D, the Core C, the shoe N, then around the windings on the shoe and to the controller and motors, from which it flows to the frame of the car and through the wheels to the rails and the ground.

One point in favor of this system, in addition to

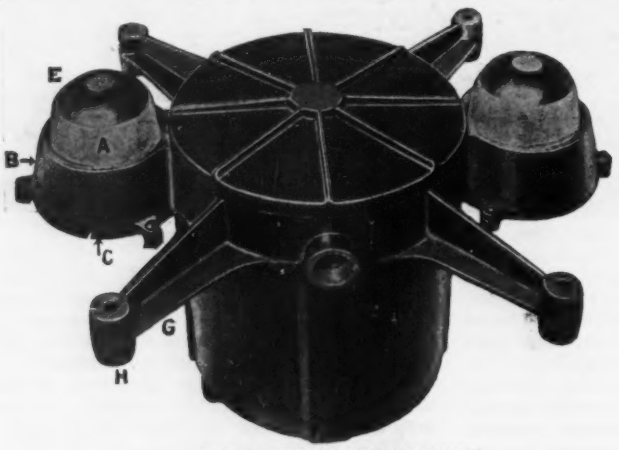



FIG. 8. COMBINATION UNIT.

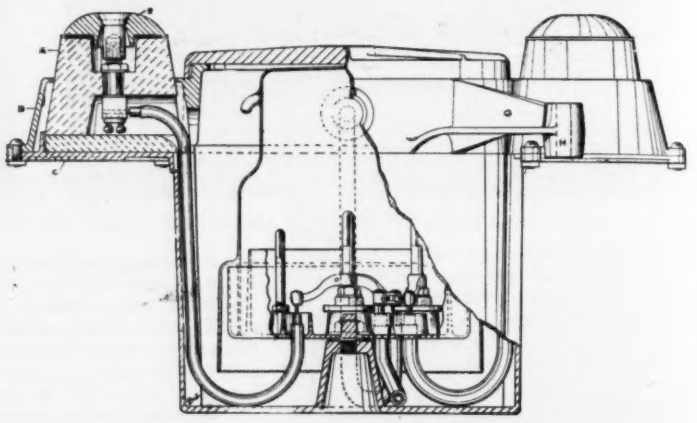


FIG. 9. SECTION OF COMBINATION UNIT.

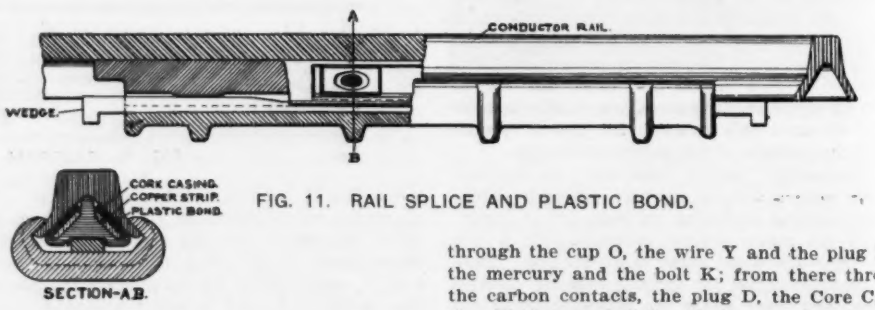



FIG. 11. RAIL SPLICE AND PLASTIC BOND.

its comparative simplicity, is that there are no windings in the switch, and hence very little self-induction, allowing the current to be broken with very little sparking. Also, the switches may easily be removed for inspection and repair. The Diatto system lends itself very conveniently to a mixed trolley and surface contact road, as, indeed, any surface contact system would do.

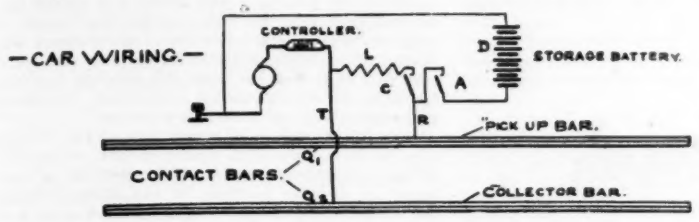



FIG. 5. DIAGRAM OF CAR CONNECTIONS.

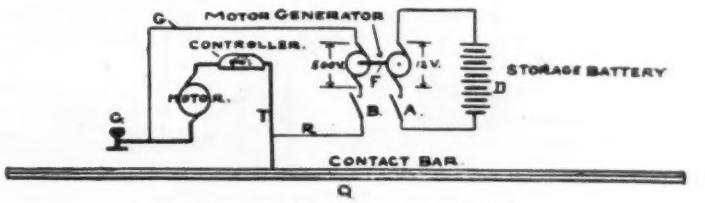



FIG. 10. CAR-WIRING FOR SINGLE RAIL.

For the information here given concerning this system we are indebted to the Compagnie Industrielle de Traction, 28 Rue du Rocher, Paris, France.

## STEEL FRAMING FOR FREIGHT CARS.

A paper on this subject, read before the Western Railway Club by Mr. G. W. Scott, of the Pullman Co., was printed in our issue of March 28, and we give herewith some extracts from the very brisk and interesting discussion:

Mr. S. P. Bush (C., M. & St. P. Ry.).—Mr. Scott takes the position that trussing underneath the car is not desirable. We have used cars for a great many years with under-trussing that has served a splendid purpose. It may be that it can be dispensed with, but it is not entirely clear to me why it should be. I do not see any real objection to a truss rod applied to a steel frame. I believe you can get more carrying capacity with less dead weight by sticking to it.

He brings up another important principle, and says:

A system of under-framing, in which the greatest possible proportion of the vertically applied loads shall be transmitted in the most direct manner to the center plate without producing a bending moment in the body bolster.

I do not quite understand why it is necessary to carry all the load on the center plate. We never have. In fact, there are a great many reasons why we should not carry the load on the center plate. You require a heavier truck bolster and also a heavier body bolster, and it means more expense and more dead weight.

He also says:

A system of under-framing consisting of members having equal upper and lower flanges, between which the horizontal forces from and through the drawbars may be transmitted.

The reason why it is necessary to have equal upper and lower flanges is not quite clear. Again, he says:

A system of under-framing having a central rigid connection for the purpose of transmitting direct from drawbar to drawbar the shocks due to impact, in addition to the ordinary stresses consequent on the movement of the car or train.

Now, I do not see why it is necessary to have a single member. That increases the distance between the central member and the next member. The floor has got to be supported, and you have got to introduce something intermediary to support the floor. It seems to me when you get through with adding those things that are necessary to support your floor, you not only have as much dead weight, but possibly more, by confining your construction to a single member than by having the two. That single member makes it necessary to apply between your body bolster and your end sill two members which will be used for attaching the draft gear. It seems to me that it is an open question whether it is not better to have your center members run right straight through your car. If it does, that portion which extends from the body bolster to the end of the car acts as a cantilever to support quite a load; it not only supports that part of the load which projects over the bolster, but it also serves to hold up the load in the middle of the car. In that way it is very valuable.

Again, with those two members getting the constant pushing and pulling that must come, it does seem to me a uestion whether, with riveting as it is ordinarily done, there is not going to be a great deal of difficulty in keeping those two members tight in place.

Comparisons of weights of cars should not be made merely on the basis of their marked capacity. We see a great deal of that in railway papers, and there is no reference made whatever to the actual strength of the car or its factor of safety; or, in other words, the fiber stress that is used in construction, and nothing is said as to the cubic capacity. You might have a car of 100,000 lbs. capacity and 3,000 or 4,000 cu. ft. capacity, and you might have another one of 100,000 lbs. capacity, and have double that cubic capacity. It is unfair to compare weights except on that basis, and it is also manifestly unfair to make any comparison in weights without making some reference to the factor of safety. I believe that is a principle that the Master Car Builders' Association could very well take up. They could adopt a standard fiber stress in certain important members of the car of 12,000 or 13,000 or 14,000 lbs., whatever the figure might be. That would have a strong moral influence in regulating construction, and it would be a decided economy in the long run to the railways.

Mr. G. R. Henderson (C. & N. W. Ry.).—The author advocates the use of materials which may be obtained as nearly as possible in their finished forms, and throughout the country at large, and preferably independently of any manufacturer. I think this is one of the most important points which should be observed in the building of steel cars. The great objection I have to the pressed-steel shapes is, that if they are manufactured by an Eastern concern, and if the car should happen to be in the West at a time when repairs should be made, there would be a great delay in getting material to the point where the repairs are to be made. If they are made up of structural shapes, these can be obtained from almost any manufacturer; and now, since the different steel makers have adopted the American standard sections, which are practically the same all over the country, there certainly should be less time lost and less expense in making repairs to foreign cars when they are far away from their home road.

In regard to the author's demand for "a system of under-framing competent to carry the whole of the dead and applied loads without assistance from any associated upper structure, and no less competent to hold up, structurally unimpaired, under the general conditions of car service," I have always felt the same as Mr. Scott in regard to steel framed cars. I think it is quite an advantage to have the car framing strong enough. We had, on the Norfolk & Western, quite a number of tender frames which were practically flush underneath same as on top, and in case of a collision the damage to the frame was very small; in fact, $20 or $30 worth of work would put one in as good shape as ever; whereas, if there is a lot of rigging underneath, it is easy to be seen that it is more readily destroyed. As to truss rods, while I can see no special objection to them, yet I agree with Mr. Scott that it is desirable to make the structure strong enough without them. There is one thing in steel car construction which has been omitted, and which I think is a valuable point, and that is to provide a wooden end sill. I would have a complete metal structure, and at the end have a wooden sill of 8 or 10 ins. When the cars do get together and these timbers come into play, you have a soft structure there to interrupt the blow, and it will save a great deal of trouble and prevent a short life by absorbing the blow. This wooden sill gives good results, and it can be replaced whenever a new one is required. It will prevent a great many dents and other troubles with the end frames of the cars. In regard to the comparison between the strength of cars and the rated capacity, I agree fully with Mr. Scott and Mr. Bush. A good method is to give full loading of the car, or loading 20% above the marked capacity, and then state the deflection at the center. This gives a good idea of the relative strength of the different constructions.

Mr. G. W. Scott: I advocate the rigid construction criticised by Mr. Bush because of the practically indeterminable character of the shocks and stresses to which a car is service is subjected. If in designing a car framing we consider only the vertically applied loads, then the regular bridge construction, with its tensional and compressive members, would be in order. But, unlike a bridge, a car must be stiff enough to withstand end shocks of no mean character applied through the drawbars, and I submit that for such stresses the design given in Fig. 1 (Eng. News, March 28) is not without its distinct advantages. The absence of truss rods, needle beams, etc., under a car is also desirable, in that it affords ready ac-

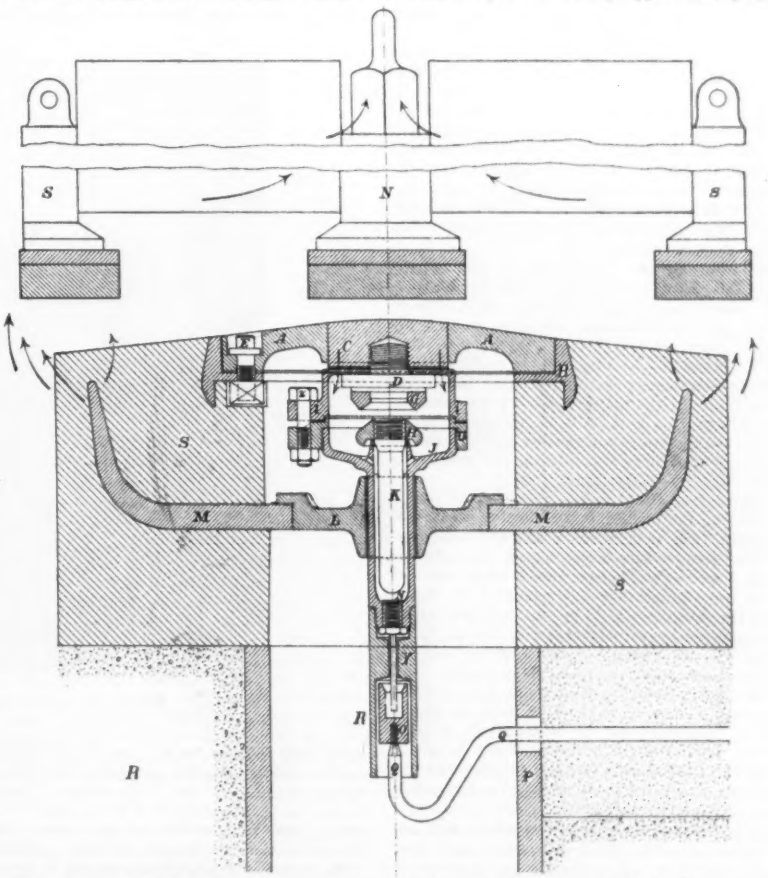



FIG. 12. CROSS-SECTION OF THE CONTACT SHOE AND AUTOMATIC SWITCH OF THE DIATTO SYSTEM.

cess for those engaged in the work of inspection and repairs.

In his comments concerning proposition No. 5, in regard to center plates, Mr. Bush questions what I consider one of the strongest features in the design. It is based on the assumption that it is proper that the car and its load shall be normally carried on the truck center plates, and that the side bearings shall be considered only with reference to limiting the rocking motion of the body of the car. With this consideration in mind, the proposition becomes a simple problem in engineering, and its solution lies in delivering the load in the most direct manner to the body center plate, and this in turn to the truck center

FIG. 13. PERSPECTIVE VIEW OF THE CONTACT SHOE.

plate. For whether we use few or many body sills, the load will, in a properly designed truck, finally come upon the truck center plate; and so far as the load upon the center plate is concerned, it is obviously immaterial how many sills may be employed in the framing. But it is quite different with respect to the strength of the body bolster, for here the question is vitally concerned with the number and disposition of the longitudinal sills, the total bending moment in the body bolster being the sum of the several independent bending moments set up by the loads transmitted by the sills to the body bolster. Hence the obvious advantage of using a single center sill capable of delivering its full load directly over the truck center plate.

Both Mr. Bush and Mr. Henderson prefer the use of two center sills extending from end to end of the car. On this point I would say that running center sills from one end of the framing to the other necessitates the attachment of side and intermediary pieces to form the body bolster, or else of a separate bolster placed beneath the sills. Inasmuch as the body bolster is a decidedly important member in a car framing, it should, to my mind, be structurally complete in itself; and if we can employ it as a distinct member in the car framing itself, as shown in Fig. 1 (Eng. News, March 28), the advantage is still more pronounced.

Mr. J. H. Mitchell (Pressed Steel Car Co.): In looking over this paper I find that unfortunately Mr. Scott does not give any figures in regard to the sections he used, so that no mathematical deductions can be made, but the general principle which he has used seems to be at fault in many points. He has lost sight of one of the primary points in construction for railway equipment, that is, minimum weight with maximum strength. We feel certain that the design of under-framing shown will weigh at least 2,000 lbs. more than the pressed steel construction for 100,000 lbs. capacity flat car.

The use of one center sill will not be able to meet the requirements, especially in 100,000-lb. cars. The tendency of this section, especially in a long car, will be to buckle, due to the end thrusts on the couplers, and the section of this I-beam would have to be made so deep that it would necessitate a very heavy beam, besides making the body bolster deep on account of its connection with the center sill. In the old style of sills the thrust is transmitted through two sills, and is, therefore, better taken up by a larger area, thus causing less damage to each respective part, such as the bracing, and everything that comes in contact with the center sills.

The great number of rivets in the body bolster, which are concentrated at the center, would tend to weaken it very considerably. For that reason a single I-beam construction for the body bolster would hardly be sufficient, for the strongest part of the bolster should be at the central point. He has strengthened this somewhat by means of braces, but the strength should be in the bolster itself. A weak point in the end construction is the bracing. There is no brace for the coupler horn on this framing, and the construction as shown would not be able to stand.

In pressed steel under-framing, throughout the entire design, the question of maximum strength with minimum weight has been considered, as, for instance, in the side and center sills. One of the advantages of this design of sill is the elimination of about 1,000 lbs. of material from the weight of the car as compared to that built of rolled steel channels of equal strength.

In the pressed steel under-framing, two center sills are used which are braced with pressed steel diaphragms having flanges, so that it is not necessary to rivet on an angle connection for fastening them to the sills, thus avoiding the extra handling and cost of manufacture, and the eliminating of a number of additional parts, and at the same time strength is maintained.

In the center and bolster construction of the pressed steel under-framing, the parts are joined in such manner as to reinforce one with the other and materially add to the strength and the value of the body bolster. The body bolster is constructed of such shape and design as to afford the best support to all the parts it comes in contact with, thus distributing the thrusts and concussions, and thereby materially increasing the durability of all the parts.

In answer to Mr. Scott's remarks regarding the injury to the metal due to the distorting and straining action in the process of manufacturing pressed steel, I would say that the designer of the pressed steel parts has designed each part that in the course of manufacture the parts will not be strained or distorted, but are so shaped as to afford greater strength than can be produced from a rolled shape of the same weight. A great deal of our large pressing is done cold, while the smaller and irregular shapes are pressed hot, and up to the present we have not had any failures from this.

Mr. F. H. Stark (C., L. & W. Ry.): I believe the under-framing should be designed, as far as possible, regardless of the capacity of the car, with a view of maintaining the same lengths and sections. In other words, by adding two more members we could acquire greater carrying capacity, for instance, a six metal sill car for 60,000 lbs.; an eight metal sill car for 80,000 lbs. capacity. It is almost necessary to have the same dimensions of center sills, the same strength in the end sills, and the same floor supports, whether it be a 30-ton car or a 50-ton car. These lighter capacity cars must run in the trains with the heavier capacity cars, and the shocks incident to railway service are practically the same in one capacity car as they are in another.

It might be desirable to carry the whole load on or through the car sills, but I notice in the steel gondola cars that are built on this principle, that the dead weight is equal to that of a well-designed modern composite car, and I see no reason why we cannot use the upper structure of cars to aid the under-frame. Surely, in a box car we must have side walls sufficient to hold the wall vertically against bulging, and we might just as well use them to help carry the load. In our present practice we never truss a box car as we do a flat car.

I agree with Mr. Henderson that it will be a good idea to have an oak sill in addition to the metal end sill. I saw some cars designed by the Norfolk & Western R. R. recently, and the wooden end sill is fitted in between the flanges of the metal sill. This stiffens it horizontally, and if the car is cornered, or if it is pushed in on a siding with a push pole, it does not so readily destroy the end sill as it does in the present all metal construction.

The question of a draft attachment is the most difficult problem to solve. With the steel construction the longitudinal members being of steel, there does not seem to be any elasticity to take up the shock, as is the case with the wooden car. I believe we must design something that will give us more spring capacity. A travel of 1¾ to 2 ins. is not enough to consume the enormous shocks of these large cars coming together.

As to the point raised by Mr. Bush regarding the whole of the loading being transmitted to the center plate, I presume he has in mind the practical roller side bearing. We all appreciate that if we had this we could reduce the weight of the truck bolster and body bolster some 600 lbs. per car; there would be that much less weight, and with a practical and durable side bearing we would accomplish the same result in allowing the truck to rotate freely and relieve the flange wear, and decidedly reduce the dead weight of the car.

Mr. Scott: Two cars were built by the Pullman Co. in accordance with the general lines referred to in the paper, one a box car and the other a gondola or coal car, both built for a carrying capacity of 80,000 lbs. On the completion of the gondola it was loaded with 120,000 lbs. of bar iron, and with this 50% overload was bumped over frogs and crossings in a portion of the Pullman works. Despite this excessive overloading, the body side bearings were well apart from the truck side bearings, and the deflection of the side sills did not exceed ⅝-in., the deflection disappearing with the unloading of the car.

Later, the gondola was turned over to the Chicago & Alton R. R. and placed in regular service. Subsequently the car was subjected to test, which consisted of running the car at 25 miles per hour, on two different occasions into a train of old and standing cars; and that for a third test the car was run cornerwise into a box car. I am not informed as to the result of the test so far as the cars are concerned which were run into, but with regard to the gondola the only damage done was the failure by fracture of some gray iron castings used in the trucks, and also of one cast-iron center plate, the framing, however, remaining intact save for the failure of one of the corner braces. Presumably this fracture occurred during the third test, and as a result of the heavy bending moment set up in that member by the corner shock.

Mr. J. J. Hennessey (C., M. & St. P. Ry.): I fully agree with Mr. Scott that the coming car should be of commercial shapes—shapes that can be produced by the railway companies all over the country. It would be almost impossible to get pressed steel shapes for the different lines of cars without going to the manufacturer for it.

I do not agree with the idea of having one sill in the center. There should be two center members extending the whole length of the car, to form what is commonly called now the draft timbers. With the single center member you have to use short draft timbers, and in buffing you strike below the center line, and there is a tendency to bend the end down and the center up. In pulling, it is just the reverse.

We have all advocated for years the carrying of loads on the center plates, but any man who will go through

FIG. 14. VIEW OF CAR TRACK BEING EQUIPPED WITH THE DIATTO SYSTEM.

our railway yards to-day will find the percentage of the loads carried on the center plates is so small that it is hardly worth considering; 95% of the cars come down solid on the side bearings. There should be something done to greatly strengthen the body bolsters and truck bolsters, and the only way is to put an enormous amount of metal in the bolsters, otherwise it will be necessary to carry part of the load on the side bearings.

Mr. Scott: With regard to the upper framing for a box car, it is assumed, for this construction, that the under-framing is competent to carry the whole of the vertical loads, and that the upper structure is merely intended to support the box part of the car. The framing, however, should be sufficiently strong to take care of stresses due to shifting loads, inertia of the parts, etc., but in nowise to be considered as an element in carrying the load. The diagonal braces involved are simply tension rods, and their purpose is to prevent movement of the upper portion of the car relative to the lower portion.